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ABSTRACT

The purpose of the study was to conduct preliminary research to acquire an understanding of the conditions, constraints and parameters that could influence the design, preparation, and conduct of a demonstration involving computer managed instruction by satellite, as well as explore what communications systems would be available to become operational should the demonstration results indicate this is desirable. Eight basic areas of research were undertaken during the feasibility study. The goals of the research were to determine: (1) the key requirements that must be met to conduct a demonstration; (2) the preferred communications system; (3) the CMI course that could be used for the demonstration; (4) the operational potential of the demonstration objectives; (5) the demonstration design options that could yield the desired results; (6) whether an economic model could be developed to conduct a cost-effectiveness analysis; (7) the demonstration tasks and schedule for their execution; and (8) the communications systems suitable for operationalizing the concept, if the concept is found viable. The research results led to the conclusion that the demonstration is feasible, and it was recommended that the design work be undertaken. (Author)

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TAEG Report No. 44

COMPUTER MANAGED INSTRUCTION AT REMOTE SITES BY SATELLITE: PHASE I, A FEASIBILITY STUDY

BEST COPY AVAILABLE

This Report was Prepared by

Kenneth A. Polcyn, Ph.D.
Principal Investigator

E. Scott Baudhuin, Ph.D.
Henry T. Ingle, Ph.D.
Bernard E. Keiser, D.Sc.E.E.
Bernard H. Rudwick, P.E.
William E. Woods

of

PRC Information Sciences Company

for the

Training Analysis and Evaluation Group

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Alfred F. Smode

ALFRED F. SMODE, Ph.D., Director
Training Analysis and Evaluation Group

WORTH SCANLAND, Ph.D.
Assistant Chief of Staff for
Research and Program Development
Chief of Naval Education and Training

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of the study was to conduct preliminary research to acquire an understanding of the conditions, constraints, and parameters that could influence the design, preparation and conduct of a demonstration involving computer managed instruction by satellite, as well as explore what communications systems would be available to become operational should the demonstration results indicate this is desirable. Eight basic areas of research were undertaken during the feasibility study. The goals of the research were

to determine: the key requirements that must be met to conduct a demonstration; the preferred communications system; the CMI course that could be used for the demonstration; the operational potential of the demonstration objectives; the demonstration design options that could yield the desired results; whether an economic model could be developed to conduct a cost-effectiveness analysis; the demonstration tasks and schedule for their execution; and the communications systems suitable for operationalizing the concept, if the concept is found viable. The research results led to the conclusion that the demonstration is feasible, and it was recommended that the design work be undertaken.

FOREWORD

The U.S. Navy, confronted with increasing training costs and marginal operational manning, has attempted to improve its posture by developing a self-paced, Computer Managed Instruction (CMI) System, which has proved to be successful for the initial training of personnel. The success of the system has prompted further research to explore greater economies and improved manning through the use of communication satellites to deliver CMI at remote job sites. The project is called Computer Managed Instruction by Satellite (COMISAT).

The project is sponsored by the Cybernetics Technology Office, Defense Advanced Research Projects Agency (ARPA) and the Research and Program Development Office, Chief of Naval Education and Training (CNET). CNET's Training Analysis and Evaluation Group (TAEG) serves as the COMISAT Project Officer for CNET and as the Contracting Officer's Technical Representative (COTR).

Planning Research Corporation Information Sciences Company, working with ARPA and CNET/TAEG, is responsible for the project background research and the design, development, implementation and evaluation of the demonstration.

Others in the project management organizational structure include various commands and agencies of the U.S. Navy: the Bureau of Naval Personnel will provide the required personnel; the Naval Telecommunications Division, Chief of Naval Operations, is to approve the use of the Navy telecommunications system for the demonstration; the Naval Education and Training Information Systems Activities will provide computer support; the Chief of Naval Technical Training will provide the CMI course; and the Navy Personnel Research and Development Center will provide support in those areas in which they have conducted relevant research.

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Many individuals have contributed to the COMISAT Feasibility Study. We are grateful to the Advisory Board which periodically met to review the progress of the program and when necessary to provide guidance. Members of the Advisory Board are Dr. Worth Scanland, CNET; Dr. Harry O'Neil, ARPA; Dr. A. F. Smode, TAEG; Dr. N. J. Applegate, CNET; Mr. Andrew W. Bright, OP-124; Mr. John Campbell, DSS-W; CDR J. Davis, CNTT; Ms. Bonnie W. Dunning, OASD (M&RA); CAPT R. E. Enright, OP-941E; Dr. Marshall Farr, ONR; LCDR T. L. Ferrier, COMTRAPAC 31; Dr. John D. Ford, NPRDC; CAPT R. B. King, BUPERS; CDR W. H. Leuker, OP-983; Mr. Wasyl Lew, NASA; Mr. M. K. Malehorn, OP-099; Mr. C. S. Mathews, MARAD; CAPT D. F. X. McPadden, CNET; LCDR K. J. Plis, OPNAV 943; Mr. R. E. Potts, CNET (N-721); Mr. Walter Primas, OP-39; CDR D. L. Ricketts, COMNAVTELCOM; LCDR J. K. Ruland, OP-124D; LCDR S. M. Skie, OP-941E; Dr. R. G. Smith, OP-987; CDR G. A. Steenstra, COMOPTEVFOR; Mr. Charles M. Tilly, NETISA; COL G. P. Tilson, OASD (M&A); CAPT J. L. Townley, OPNAV OP-39; LCDR C. J. Waylan, NAVELEX; Mr. A. W. Wilcox, NAVELEX.[1]

Personnel at CNET and TAEG who were extremely helpful included Dr. Gene Micheli, TAEG, COMISAT Project Officer and Contracting Officer's Technical Representative (COTR); Mr. Ed Scheye, CNET; Mr. Ed Moore, TAEG; Mr. Clarence J. Papetti, TAEG; Dr. William Swope, TAEG; and Mr. Morris Middleton, TAEG.

---

[1] Individuals associated with the Advisory Board are not listed again in their respective contributing organizations or commands.

Members of CNTECHTRA and NETISA provided inputs regarding the operation of the current CMI training system as well as projects involving future improvements to the system and future courses to be developed. The CNTECHTRA personnel included Mr. Dwayne Chambers, Mr. Stuart Carson, and Dr. Norman Kerr. NETISA personnel included Mr. Joe Harvill, LT Charles Sharrocks, and Ms. Phyllis Salop.

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EXECUTIVE SUMMARY

A. COMISAT Project

1. Background

The acceleration of military personnel costs has caused military personnel managers to seek ways to obtain more in return for dollars expended and, where possible, to stabilize or reduce costs. One major source of accelerated costs is training, a continuing and necessary requirement.

In an attempt to address the training cost problem, the U.S. Navy developed a self-paced, computer managed instruction (CMI) system, which became operational in 1973. First, a set of prioritized skills were derived from task analysis. These skills were translated into learning objectives and then into learning modules with accompanying self-paced learning materials and performance measures. The learning modules were then automated through CMI.

Thus far, the achievements of the CMI system, which provides a means for guiding and counseling students through a continuum of instruction with only minimal staff support, have been dramatic. The system has significantly reduced course time, instructional and support personnel, and student attrition; it has significantly increased student end-of-course achievement levels; and it has been estimated to have saved over $10 million in FY 1975 alone.

The computer facility is located near Memphis, Tennessee, and is accessed via terrestrial lines from Navy training facilities throughout the United States. In addition to Memphis, training facilities which are currently using the CMI system are San Diego, Great Lakes and Orlando. At this time, there are about 5,000 students on the system on a daily basis.

The success of the CMI system in the continental United States prompted the Chief of Naval Education and Training (CNET) and the Defense Advanced Research Projects Agency (ARPA) to become interested in determining the practicality of, and resource requirements for, extending the system to Navy personnel at sea or other remote locations. More specifically, the question is being asked: Can further improvements in resource use be effected by delivering CMI at job sites?

2. Purpose and Objectives

The purpose of the research project is to evaluate the cost effectiveness of instructional support delivered at job sites under the direction and control of a centralized CMI system.

The related objectives of the effort are:

- To determine whether CMI delivered to remote sites produces the same learning effectiveness as CMI does in the learning center environment
- To determine whether CMI delivered to remote sites is as economical as CMI in the learning center environment
- To determine whether the attitudes of students, trainers, and key remote site personnel are supportive of CMI delivered to remote sites
- To determine the personnel requirements
- To determine the personnel training requirements
- To determine the organization and management structure requirements
- To determine the remote site space requirements and operational procedures for effective use of a CMI training support system
- To determine the equipment, maintenance, spare parts, and logistics requirements

3. Study Phases

As originally conceived, the research effort was expected to take 29 months and have five phases: a 9-month feasibility study; a 4-month demonstration design; a 6-month demonstration preparation; a 6-month demonstration; and a 4-month evaluation.

The first phase, which is now complete and is the subject of this report, included gathering background data and information, establishing resource requirements, and setting the parameters for the demonstration. The second phase will use the information from phase one to determine the most useful approach for conducting the demonstration; in this phase the research approach will be defined and a detailed plan for its preparation, execution, and evaluation specified. The third phase will focus on bringing the demonstration to an operational state through implementation of the design detailed in phase two; in addition, a trial run is planned to ensure that all aspects of the demonstration are functioning properly before the actual demonstration begins. The fourth phase will include executing and monitoring the planned demonstration activities, making adjustments or changes as necessary, collecting data and information, preparing it for analysis, and conducting initial analyses.

The fifth phase will involve evaluating and summing up the results of the demonstration, drawing conclusions, and making recommendations.

It should be noted that formative evaluation is being conducted throughout all phases. This continuous evaluation will furnish project personnel with information helpful to them in assessing the status, quality, and progress of the products, procedures, and organizational aspects for which they are responsible and will ensure that satisfactory progress is made in developing and executing the demonstration.

B. Feasibility Study

1. Purpose

The feasibility study phase was initiated April 1, 1976 and concluded December 31, 1976. The purpose of the study was to gain an understanding of the conditions, constraints and parameters that could influence the design, preparation and conduct of a demonstration, as well as to explore what communications systems would be available for an operational system.

2. Work Tasks

Eight basic areas of research were undertaken during the feasibility study. The goals of the research were to determine: the key requirements that must be met to conduct a demonstration; the preferred communications system; the CMI courses that could be used for the demonstration; the operational potential of the objectives; the demonstration design options that could yield the desired results; whether an economic model could be developed to conduct a cost-effectiveness analysis; the demonstration tasks and schedule for their execution; and the communications system suitable for operationalizing the concept, if found of value.

a. Key Requirements

It was determined that five basic requirements must be met to execute the demonstration.

- Approval for the use of an existing communications system
- Approval for the use of the U.S. Navy CMI computer facility at Millington, Tennessee
- Selection of a validated CMI course for the demonstration
- Identification and commitment of a specific operational site to conduct the demonstration
- Identification and commitment of specific U.S. Navy personnel to participate as subjects and to act in a support capacity

Of the five requirements, the first three have been thoroughly analyzed and checked with the potential contributors: a possible communications system has been defined and tentatively approved by all individuals to be involved except the site commander; the use and function of the CMI computer facility has been defined and tentatively approved by NETISA; and the existing CMI courses have been analyzed and possible candidates identified. The other two requirements, which are interrelated, have been analyzed but necessary commitments have not been obtained.

b. Preferred Communications System

To determine the preferred demonstration communications system, it was necessary to conduct an analysis of the available options including the NASA Application Technology Satellites (ATS) 1, 3 and 6; the standard Navy message system and voice circuits; domestic commercial satellites; ARPANET system; and the High Frequency (HF) AUTODIN system.

The analysis included the calculation of data requirements in terms of the quality of data to be transmitted from the demonstration site to the CMI computer and return and the response time required; and the evaluation of the alternatives in terms of performance provided and costs incurred for the demonstration.

The standard Navy message system was found to be the preferred communications system. This system would function as follows.. Messages coming to the demonstration site would follow normal message traffic paths, with student information being routed to the designated training contact point for distribution to the student. Student messages, i.e., tests, leaving the site would be entered into an OpScan 12/17 Source Document Reader, converted to paper tape, and transported to the site message center. There, they would be placed in the normal message queue and transmitted in encrypted form via the standard communications path to the fleet center designated for the particular geographical area. The message would then proceed over the AUTODIN system and be routed to the Memphis NAS TCC. At the Memphis TCC, the digital message would be automatically decrypted and converted to paper tape and page copy form. For the purpose of the demonstration, the paper tape and page copy would be transported by hand to the Memphis CMI center, where it would be processed. The return messages, i.e., test results and prescriptions, would be outputted in the form of a paper tape. In the return leg, the paper tape would be delivered to the Memphis Message Center, where the reverse transmission path would be followed back to the site.

c. CMI Courses

Seven courses were analyzed to determine their potential for use in the demonstration. Of these, five--Basic Electricity and Electronics (BE&E), Aviation Fundamentals (AFUN), Aviation Machinist Mate (ADJ), Avionics (AV) and the common core for Boiler Technician (BT), Machinist Mate (MM) and Engineman (EN)--are currently on CMI; one--Radioman (RM)--will soon be on CMI; and one--General Damage Control (GDC)--is a possible candidate for CMI.

Of the seven courses analyzed, the RM course, which ends with a rating, appears to be the best suited for the demonstration; this course would be applicable whether the demonstration site is a land base or a ship. However, if a ship is specifically interested in a course that would aid in the improvement of its operational effectiveness, the GDC, if placed on the CMI system, would be applicable. Since BE&E and the common core for BT, MM and EM are prerequisite courses, their applicability would be limited to site personnel who missed them for some reason or who wish to change rates.

d. Objectives' Operational Potential

The eight project objectives were analyzed to determine whether measures could be defined to operationalize them and whether instrumentation exists, or would have to be devised, to collect the data.

It was found that all objectives can be operationalized and that instrumentation either exists or can be devised for collecting most data. However, care would be needed in developing data collection approaches for all except Objective 1, which is handled by the CMI system. Because of its comprehensiveness, Objective 3 could be the most difficult to achieve.

e. Demonstration Design Options

In an effort to determine whether a suitable research design could be developed for the demonstration, a number of alternative designs were explored. Two basic designs were found to be best suited for the research: the traditional pretest/posttest control group design, where random assignment of subjects to research conditions is assumed; and the non-equivalent control group design, where the treatment is randomly assigned to existing groups of subjects.

The first design has applicability if new personnel are used as subjects; the second design if existing personnel are used. In either case, for statistical reasons a minimum of 60 subjects would be desirable--30 for the experimental group and 30 for the control group.

Concerning the first design, an acceptable approach would be to randomly assign personnel entering the Navy to the control and experimental groups. All subjects would initiate their training at an A-school. The experimental group would receive a portion of their training at the A-school and then be assigned to an operational (demonstration) site(s) for the remainder of the CMI training, which would be interspersed with normal duties. The control group would complete their A-school training at the schoolhouse and be assigned to normal duty stations. Measures of the experimental group's course module success would be taken over time and compared--in terms of time to complete and, where applicable, level of achievement--to the control group's success in completing those same course modules.

The second design approach would be applicable if new, partially trained personnel would not be acceptable to a demonstration site. In this situation, a subset of existing personnel at the demonstration site would be selected to be the experimental group; the control group would be selected from a number of A-school classes taking the same course. Comparison would be made as in the first design.

f. Economic Model

The objective of the economic model work was to arrive at a theoretical cost model which could be used to compare possible design options for an operational CMI system. The model addresses the preferred system for different future time periods and student load conditions, all of which would be input to the development of a master implementation plan, if the concept is found to have merit.

The economic model is based on two assumptions. First, the only training system alternatives to be evaluated are those using a form of CMI; therefore, training systems using Instructor Managed Instruction (IMI) or traditional classroom instruction were not considered. Second, the performance and cost data to be used will be based on the current operational CONUS-based CMI system, the COMISAT demonstration and the NPRDC minicomputer CMI demonstration.

g. Project Tasks and Schedule

Work to be conducted during the last four phases of the project has been analyzed in light of the status of the five conditions noted earlier as well as other factors which might influence schedule slippage. Because a site, a course and personnel to be used for the demonstration were not specifically identified during the feasibility phase, there is likely to be a 2- or 3-month delay in the start of the demonstration. The start date would then be January or February 1978, rather than November 1977 as originally planned.

h. Operational System

In order to determine whether the COMISAT concept could be operationalized given a successful demonstration, an analysis of alternative communications systems was conducted. The analysis covered all satellite and other communications systems that might be available on a worldwide basis to handle the additional message traffic generated by the CMI function and included consideration of the possible impact of current Joint Chiefs of Staff (JCS) policy directives on an operational COMISAT system. Based on the analysis of the systems and the varying communications loads that were postulated, it was concluded that operational systems would be available to handle some CMI-type training data.

C. Conclusions

As a result of the feasibility study, the following conclusions were reached:

- The U.S. Navy communications system should be used for the demonstration.

- The proposed demonstration is technically feasible and can be operationalized with existing hardware and within the current Navy communications system.

- The additional resource requirements for the conduct of the demonstration are relatively small and should pose no major obstacle.

- Each objective can be realistically operationalized and the associated data collected.

- The available or soon to become available CMI courses would be adequate for the purpose of the demonstration.

- A research design can be developed which would yield the desired project results.

- Keeping the original project schedule is highly unlikely, requiring a 2- to 3-month slippage.

- Technically, it would be possible to operationalize the COMISAT concept, since the present and future Navy communications and NETISA computer systems would be able to support some operational site training.

D. Recommendations

Based on the conclusions, the following recommendations are made:

- Pursue the project into the design phase.

- Continue to seek a demonstration site--land or sea--for the conduct of the demonstration.

- If a demonstration site is not designated within the design phase, terminate the project.

- If a demonstration site is designated within the design phase, plan for a January or February 1978 demonstration start date.

Chapter I

INTRODUCTION

A. Background

This joint Defense Advanced Research Project Agency (ARPA)/Chief of Naval Education and Training (CNET) research effort was prompted by the increasing cost of resident schoolhouse training and the need for a means to support training at job sites to improve operational readiness. The U.S. Navy was selected to be exemplary of the needs and problems associated with an operational military unit since the Navy operational environment represents the epitome of remoteness that might be expected of a military unit and therefore offers a unique challenge; in addition, CNET has developed a self-paced Computer Managed Instruction (CMI) system which has direct application to the research problem. Further, the Navy has developed a reliable communications system that permits communications with any naval site in the world.

1. CMI System

In an attempt to address the training cost problem, the U.S. Navy developed a self-paced CMI system which became operational in 1973. The systems approach to instructional development was used to provide a set of prioritized skills derived from task analysis; these skills were translated into learning objectives, then into learning modules with accompanying self-paced learning materials and performance measures. The learning modules were then automated through CMI. In effect, CMI provides a means for guiding and counseling students through a continuum of instruction with only minimal instructor staff support.

The computer facility is located at Millington, Tennessee, near Memphis and is accessed via terrestrial lines by Navy training facilities throughout the U.S. Training facilities besides Memphis which are currently using the CMI system are San Diego, Great Lakes, and Orlando. A total network to include most A-school training sites is to be completed in the future.

In the resident training environment, the achievements of the CMI system have been dramatic. It has significantly reduced course time, instructional and support personnel, and student attrition; it has significantly increased student end-of-course achievement levels; and it has been estimated to have saved over $10 million in FY 1975.[1]

2. U.S. Navy Communications System

The U.S. Navy communications system is comprised primarily of cable, high frequency (HF), and communications satellite components. The satellites are recent additions to the system, with the first becoming operational over the Atlantic Ocean in April 1976 and the second over the Pacific Ocean in July 1976; the third was launched over the Indian Ocean in December 1976 and is scheduled for operation in January 1977. Thus, the U.S. Navy has the capability to provide timely and reliable communications almost anywhere in the world.

B. Project Description

1. Project Purpose

The purpose of the research project is to evaluate the cost-effectiveness of instructional support delivered at job sites when under the direction and control of a centralized CMI system.

2. Project Objectives

Because the project is to explore the possibility of operationalizing the concept, there are eight primary objectives. They are to determine:

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[1] Worth Scanland, "Computer Managed Instruction-Navy Style," Campus. December 1975. pp. 25-27.

- Whether CMI delivered to remote sites produces the same learning effectiveness as CMI does in the learning center environment
- Whether CMI delivered to remote sites is as economical as CMI in the learning center environment
- Whether the attitudes of students, trainers, and key remote site personnel are supportive of CMI delivered to remote sites
- The personnel requirements
- The personnel training requirements
- The organization and management structure required
- The remote site space requirements and operational procedures for effective use of a CMI training support system
- The equipment, maintenance, spare parts, and logistics requirements

3. Project Phases

As originally conceived, the research effort was estimated to take 29 months and have five phases: a feasibility study; a demonstration design; the demonstration preparation; the demonstration; and the evaluation of the demonstration.

The first phase includes gathering background data and information, establishing resource requirements, and setting the parameters for the demonstration. The second phase, using the information from phase one, involves determining the most useful approach to be used to conduct the demonstration; here, the research approach to be undertaken will be defined and a detailed plan for its preparation, execution, and evaluation specified. The third phase focuses upon bringing the demonstration to an operational state through the implementation of the design detailed in phase two; in addition, a trial run is included to ensure that all aspects of the demonstration are functioning properly before actually conducting the effort. The fourth phase includes the execution and monitoring of the planned demonstration activities, making adjustments or changes as necessary, collecting data and information, preparing it for analysis, and conducting initial analyses. The fifth phase involves summing up the results of the demonstration, drawing conclusions, and making recommendations. Relative to the evaluation, it should be noted that in order to ensure that the development and execution of the demonstration is progressing satisfactorily, formative evaluation is being conducted; the purpose is to furnish project personnel with information helpful to them in assessing the status, quality, and progress of the products, procedures, and organizational aspects of the demonstration for which they are responsible.

C. Feasibility Study

The feasibility study phase was initiated April 1, 1976 and concluded December 31, 1976. This report contains the findings of the study. It should be remembered that the purpose of the feasibility study was to conduct preliminary research so there could be an understanding of the conditions, constraints and parameters that would influence the design, preparation and conduct of a demonstration, as well as to explore what communications systems would be available to become operational should the demonstration results indicate this as desirable.

The results of the study are presented in the following chapters: Chapter II discusses the five basic requirements that must be met in order to conduct a demonstration and assesses whether they have been met or are achievable. Chapter III presents the analysis which was conducted to determine the communications system which is preferred for a demonstration. Chapter IV provides an analysis of the available CMI courses which possibly could be used for a demonstration. Chapter V discusses the demonstration objectives, related measures, and the existing or needed instrumentation for data collection. Chapter VI outlines possible demonstration design options which could be used to yield the desired outcome. Chapter VII provides the economic model approach for the conduct of the cost-effectiveness analysis for providing CMI at remote sites. Chapter VIII addresses the tasks to be executed and the associated time table depending on the demonstration site and personnel to be involved and the type of course that could be used. Chapter IX analyzes the communications systems which are suitable for operationalizing a CMI system to service schoolhouse and operational unit training. Chapter X discusses the conclusions which have been reached and presents recommendations relative to the viable options available.

Chapter II

DEMONSTRATION REQUIREMENTS, CONDITIONS AND CONSTRAINTS

A. Introduction

To plan, conduct and evaluate the use of a naval communications system for providing a computer-managed instruction system at remote sites would require the cooperation and contribution of numerous U.S. Navy commands and agencies. At the outset of the Feasibility Study, entities needed to provide inputs were identified along with their possible contributions. Throughout the study, we have attempted to define the specifics of the contributions considering the conditions, constraints, and realities surrounding a demonstration, and to determine whether the contributions are possible.

Five basic requirements were established for the execution of the project: They are:

- The use of an existing communications system
- An operational site where the demonstration can be executed
- The use of the U.S. Navy CMI computer facility at Millington, Tennessee
- A validated CMI course
- U.S. Navy personnel to participate as demonstration subjects and to provide support

The key contributing commands and agencies identified to meet the requirements are:

- The Naval Telecommunications Division, Chief of Naval Operations (OP-941)

- Commander-in-Chief, Pacific Fleet, and Commander-in-Chief, Atlantic Fleet, or other command and/or agencies responsible for land sites.
- Naval Education and Training Information System Activities (NETISA), Naval Education and Training Command
- Chief of Naval Technical Training (CNTECHTRA), Naval Education and Training Command
- U.S. Navy Bureau of Personnel (PERS212)

B. Requirements and Status

1. Communications System

Initially, a NASA satellite (ATS-6) was proposed for the demonstration; but, after conducting an analysis of alternative communications systems which explored the communications needs and associated resource and time requirements for executing the project, it became apparent that the most practical approach is to use the existing U.S. Naval telecommunications system.

a. Requirements

The basic requirements for use of the U.S. Naval telecommunications system are minimal since the CMI communications can be treated as normal message traffic. This is based on the assumption that there is no need for:

- Online communications, or
- A dedicated communications channel

The communications system requirements include:

- The use of a communications link between a remote demonstration site and a U.S. Navy Communications Area Master Station (NAVCAMS)
- The use of the AUTODIN communications link between the NAVCAMS and the Memphis NAS Telecommunications Center (TCC)
- The ability to handle 62 messages per day, two emanating from the remote site and 60 returning from the CMI computer center at Millington, Tennessee

- The reception and transmission of paper tape messages at the Memphis NAS TCC
- The transmission of messages in paper tape form at the remote demonstration site TCC

b. Status

With the exception of the last item above (the remote site interface), the communications system requirements have been analyzed, operational procedures verified by COMNAVTELCOM and the Memphis NAS TCC, and tentative approval gained for their use.

Consequently, the recommended COMISAT communications system would function as follows. Messages coming to the demonstration site would follow normal message traffic paths with student information being routed to the designated training contact point for distribution to the student. Student messages, i.e., tests, leaving the site would be entered into an OpScan 12/17 Source Document Reader and converted to paper tape and transported to the site message center.[1] There, they would be placed in the normal message queue and transmitted in encrypted form via the standard communications path to the fleet center designated for the particular geographical area. The message would then proceed over the AUTODIN system and be routed to the Memphis NAS TCC. Here, the digital message would be automatically decrypted and converted to paper tape and page copy form. For the purpose of the demonstration, the paper tape and page copy would be physically transported to the Memphis CMI center, where it would be processed; and the return messages, i.e., test results and prescriptions, would be outputted in the form of a paper tape. In the return leg, the paper tape would be delivered to the Memphis Message

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[1] The use of paper tapes and couriers for interfaces should not be construed as how an operational system would function. The approach suggested for the demonstration is the result of time, resource, and policy limitations which would not permit a "hard wire" interface. However, an operational system would be designed to have electronic interfaces so that full advantage could be taken of the power of the CMI system.

Center, where the reverse transmission path would be followed back to the site, where the incoming message would be distributed as noted above.[1]

In sum, commands and agencies which are responsible for the various components of the Naval telecommunications system, except for the demonstration site interface, have indicated that the communications system would have no problem supporting the COMISAT demonstration, and they anticipate no problems in operationalizing the required support.

2. Demonstration Site

Of primary importance to the demonstration is the selection of a demonstration site. In order to determine the value of CMI for providing operational units with an instructional management system to support all types of training and reduce administrative burdens and improve the availability of assigned personnel, as well as the potential for providing portions of A-school training at the job site, it is desirable to demonstrate the concept in the Fleet or at a remote land naval base.

a. Requirements

(1) Demonstration Subjects

A requirement which would need to be imposed on a ship or remote land location is the sample size. For statistical reasons, a minimum of 30 experimental subjects would need to be absorbed or made available. To save the developmental cost of course material for the demonstration, it was assumed that existing A-school CMI courses would be selected for the demonstration.[2] Consequently, this would limit the demonstration subjects to personnel needing such training.

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[1] For a discussion of the recommended communications systems, see Chapter III.

[2] This does not necessarily preclude the possibility of a course being placed on the CMI system specifically for the demonstration.

Personnel entering the Navy as well as operational personnel who for some reason missed the particular A-school course selected for the demonstration would be candidates.

There are two classes of personnel who may participate in the demonstration as demonstration subjects; we have classified them as "new" and "existing" Navy personnel. For the purpose of this report we define these classes as:

- New Navy personnel--recruits just entering A-school
- Existing Navy personnel--rated or nonrated and assigned to an operational site

If new Navy personnel were to be used, they would need to receive part of their A-school training at a CONUS training facility to insure sufficient familiarity with aspects of the course content for the purpose of conversance and safety; at some point the students would go to the demonstration site to complete their A-school training. If personnel already assigned to the ship or remote land location were to be used as demonstration subjects, all A-school training could take place at the operational site.

To insure that the site selected for the demonstration would not be penalized if new Navy personnel were used, such personnel should be additions to the normal site manning. While additions, they should be treated as normal site personnel available for daily duties except for a period of approximately two hours a day, when CMI supported training would take place. Since CMI materials are individualized, the demonstration subjects could be scheduled throughout the normal work days; consequently, there would be no requirement for all subjects to convene for training at the same time.

(2) Equipment

By using the normal Navy communications system, the equipment requirement for the demonstration would be minimal. The site selected would need to have communications gear for quality communication with the Memphis Computer Center. If the demonstration site should be a ship, those ships with WSC-3 or -5 terminals would be candidates. Therefore, no ship communications system modification would be required. Should a land site be selected, it should have a similar type terminal for communicating via Gapfiller, or other type quality communications paths for interfacing with Memphis.

In either case, only one additional piece of equipment would need to be installed. This is an OpScan 12/17 unit, 3'x 1-1/2' x 1-1/2', weighing 75 to 100 pounds. A 70° to 80°F. environment would be needed for its operating location. The power requirements are limited to 110-120 VAC. No ECM or Tempest problems would exist. It would be necessary to have the OpScan connect with a UGC-6 teletype to produce output tape to which header and trailer would be added.

Maintenance requirements are assumed to be minimal. It is anticipated that the site's ET or other qualified personnel would be factory trained (10 working days) on the OpScan device. Preventive maintenance would take at the most two hours work per week for the period of the demonstration. Storage space would be required for one back-up OpScan and spare parts equal to one-half the size of the unit itself. Setup and takedown requirements for the OpScan would take approximately 1 day and be accomplished by either the EDTRACOM or a contractor.

(3) Personnel

Personnel needing to be accommodated at the site, other than the demonstration subjects, would be a well-versed "learning supervisor" provided by CNET; the supervisor role would be to aid students and to observe and monitor the instructional activities for the purpose of capturing representative data needed for evaluative purposes. Periodically, one PRC representative would also need to be accommodated as he visits the site to aid the supervisor.

Demands on site personnel would appear to be minimal since no interruption of normal site operations is anticipated once the demonstration subjects have been absorbed into normal work schedules and routines.

(4) Space

Space would be required for the storage and use of learning materials and for audiovisual equipment use. Storage space would not exceed an area 4'x2'x4' in size. Further, a study testing area would be required for reading, using the audiovisual equipment, testing, and accommodating the learning supervisor. The area should be able to accommodate simultaneous use by two students and the supervisor and contain at least two small learning carrels or desks and a small desk for the supervisor.

b. Status

Whether the requirements can be met is not known since no representative demonstration sites have been visited. Furthermore, a demonstration site has not been provided. However, the Commander-in-Chief, Pacific Fleet, and the Commander-in-Chief, Atlantic Fleet, and their staffs, have been briefed and a request made for a ship(s). Also, enclosure (4) to OPNAV Instruction 3960.10, which establishes and outlines procedures to obtain fleet services for test and evaluation services, should be followed. Similar approaches should be taken by CNET to obtain a remote land site.

3. Computer Facility[1]

To conduct the demonstration it is necessary to use the U.S. Navy CMI Computer Center at Millington, Tennessee. The center would function primarily as it currently does in providing training to locations in the United States. It is anticipated that some changes in operational procedure and computer programs would be needed; however, this should be undertaken with an assurance not to hamper normal operations.

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[1] For a discussion of the computer facility operation for the demonstration, see Chapter III.

a. Requirements

(1) NAS TCC--CMI Center Interface

Because of the time, costs, and policy problems associated with gaining COMNAVTELCOM approval for a communications line between the Memphis NAS TCC and the CMI center for a demonstration, manual rather than electronic communication interfaces would be required. Therefore, there would be a need for the following:

- A courier to pick up and deliver paper tape messages between the Memphis NAS TCC and the CMI center
- A UGC-6 teletype at the CMI center which can be used to read the tape containing batched student messages into the computer, and produce output message tapes to be delivered to the TCC
- Computer programs to translate the paper tape message from Baudot into ASCII code and prepare the data for normal processing; also to convert ASCII to Baudot for transmission to the demonstration site

(2) Data Identification, Processing and Output

The demonstration data would need to be identifiable so that correct messages are transmitted to the demonstration site, as well as stored for analysis. The general requirements include:

- Coding all data associated with the demonstration students for retrieval and storing it in historical files
- Batching all normal student messages and returning them to the demonstration students
- Printing administrative data and sending it to the demonstration site via a normal mail dispatch
- Providing periodic historical file tapes for analysis

(3) Operating Schedule

The demonstration would conform to the normal operating hours and days of the CMI computer center. Thus, a 16-hour Central Standard Time work day and a 5-day work week operating schedule is anticipated. However, if transmissions should occur during nonoperating hours, incoming messages would collect at the Memphis NAS TCC through a 24-hour, 7-day week period.

(4) Personnel

Additional center personnel may be required to include:

- Systems analysts/programmers to modify existing and produce new programs as required
- As noted above, a courier for message pickup and delivery
- An individual responsible for inputting the demonstration data tape to the computer and handling the output tape; handling administrative report mailing; and providing weekly historical data tapes for analysis

(5) Equipment

There would be a requirement for a UGC-6 teletype to translate the data tapes; however, this may be filled by the time of the demonstration since one is to be purchased to support normal center activities.

It is also possible that NETISA would arrange for the demonstration site OpScan 17 and associated spare parts. It is anticipated that two OpScans would be needed; one operational and one to serve as a backup. Further, it is anticipated that NETISA could arrange for demonstration site personnel (ET) OpScan maintenance training.

b. Status

The above requirements have been discussed in detail with NETISA personnel and all are within the realm of possibility given that sufficient resources and time are available. Funding would need to be made available for hiring the additional personnel and obtaining the necessary equipment.

4. The CMI Course[1]

To conduct the demonstration, at least one CMI course would need to be made available. Existing A-school CMI courses could be used, or an operational training course could be converted to CMI. Five[2] A-school courses are currently operational, with 8 expected by the fall of 1977. All courses would be candidates for the demonstration.

a. Requirements

There are a number of fundamental requirements for the selection of a course. They are:

- The course should be validated.
- It should be acceptable to the demonstration site vis-a-vis a felt need.
- Associated course materials and equipment should be storable in the available area.

Whether the demonstration subjects are new Navy personnel or existing personnel located at the demonstration site would impact the course length requirement. If the demonstration subjects are new, the course length could be greater since a portion of the training would take place at a CONUS training facility and the remainder at the remote site. However, in either case the training that would take place at the demonstration site could not exceed 250 hours. This is assuming 25 weeks of training (length of demonstration period--6 months), 2 hours a day, 5 days a week.

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[1] For a discussion of the candidate courses, see Chapter VII.

[2] These include BE&E, AFUN, ADJ, AV and the Common Core for MM, EM, and BT.

The demonstration site would also impact the course to be selected. If the site were a ship, the course selected would need to be limited in its materials and AV equipment because of limited space. Further, the course could not be one that would degrade the operational efficiency and effectiveness of the ship. Courses which require the dismantling and operation of equipment, such as maintenance training, would not be acceptable. Consequently, courses that would be candidates for ships would be limited to subjects that train personnel in equipment operations and monitoring, or address purely cognitive learning.

If the demonstration site were a remote land base, the number of candidate courses may increase since the various training aids not permitted on a ship (i.e., laboratory training devices) possibly could be provided for at a land site. Therefore, operator as well as maintenance type training courses could become candidates.

Finally, the course used for the demonstration would need to provide training equal to that received in a CONUS training facility and be a complete package which, in the case of new personnel, would culminate in a "striker" designation and immediate assignment to an operational unit, preferably at the demonstration site. In this way, students would not be penalized by the need to return to A-school to complete or retake the course and thereby slow their normal rate of advancement.

b. Status

Meetings have been held with CNTECHTRA personnel; a number of training facilities and the San Diego IPD center have been visited, and various course materials obtained. Available courses have been analyzed and five candidates identified. These include Radioman, Boiler Technician, Machinist Mate, Basic Electricity and Electronics, and General Damage Control. Assuming that the total Radioman, Boiler Technician and Machinist Mate courses are to be on CMI by October 1977, they would be the candidates if new personnel were selected to be demonstration subjects. All courses could be candidates if existing personnel were chosen as demonstration subjects. Site personnel who have not had an opportunity to attend or who passed up A-school could receive at least a portion of their training in the above courses with the exception of the General Damage Control course. Relative to General Damage Control, the majority of ships personnel would be eligible to receive training except for the hull maintenance technician personnel who receive this training at A-school. Of course, the General Damage Control course would only be applicable on a ship.[1]

5. Demonstration Personnel

Three types of U.S. Navy personnel would be needed for the demonstration: demonstration subjects, learning supervisors and maintenance personnel.

a. Requirements

(1) Demonstration Subjects

As noted before, subjects would be either new or existing U.S. Navy enlisted personnel. A minimum of 60 would be needed, 30 for the experimental group and 30 for the control group.[2] They would need to be randomly selected and assigned to groups or paired. To offset attrition, a factor equal to the normal attrition rate associated with the course of study would need to be determined and personnel added to the sample size accordingly.

For those individuals who would be selected for the project, it would be necessary:

- To determine whether involvement is in violation of recruitment contracts

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[1] For a detailed discussion of the courses, see Chapter IV.

[2] The total number of subjects that would be needed depends on the research design chosen; however, at a minimum, 60 subjects should be used if parametric statistical analysis is to be undertaken. Nonparametric analysis would permit fewer numbers to be used.

- To obtain signed permission for their participation and to gather personal information/data for the purpose of the demonstration

(a) New Personnel

Should the subjects be recruits, they would be assigned to the same CONUS training facility where the experimental group would receive a portion of their training prior to being assigned to the demonstration site for the completion of their training. The control group would receive the totality of their training at the CONUS facility, and then be assigned to their respective duty stations. From an experimental point of view, it would be ideal if both groups could be assigned to the same duty station (demonstration site). However, this is not a necessity.

As noted previously, personnel in the experimental group would need to be assigned as additions to the existing demonstration site complement and be available for normal duties, but be allowed to train at least two hours a day. Additional billets would not need to be assigned to the demonstration site over the fleet account; instead, CNET could provide for the students out of student billet allocation.

An attrited experimental subject would need to be treated like an attrited CONUS schoolhouse student. He would be assigned to normal duty at the demonstration site or another duty station. Subjects completing the course would assume regular duties at the demonstration site or another duty station if they cannot be absorbed at the site.

The control group would need to be treated as normal CONUS training students, and then be assigned to a duty station after completion of the total course. If comparisons of performance vis-a-vis the experimental group are to take place over the demonstration period as noted above, it would be ideal to assign them to the demonstration site. However, should members of the control group be assigned to various duty sites, a procedure for periodically monitoring their performance would need to be developed to insure valid comparisons. This would include:

- Establishing criteria of performance measures
- Developing a measurement procedure
- Training personnel in measurement
- Establishing a schedule for measuring performance during the demonstration period

If comparisons were to be made only using the control group's course results obtained at the completion of A-school, then there would be no need to monitor their job performance after they are assigned to their duty station.

(b) Existing Personnel

The use of existing personnel would reduce demonstration subject requirements; nevertheless, the same minimum number of subjects and background information would be needed, but the requirement for moving and absorbing personnel would be eliminated. If the demonstration site has sufficient numbers of individuals needing the training being offered, the control and experimental group could be co-located. If not, different control and experimental sites would need to be selected.

(2) Learning Supervisor

The requirements for a learning supervisor would be the same for the demonstration subjects whether they are new or existing U.S. Navy personnel. Basically, the supervisor would need to be:

- Selected from a group of volunteers
- Trained in the training procedures for the demonstration and the data collection and student monitoring functions prior to the demonstration

- Located at the demonstration site for a period of seven months--one month for the trial run and six months for the demonstration
- Available at the demonstration site to supervise learning and monitor and record student information and data as required
- Available to work with the evaluation team for at least 30 days after the demonstration

The learning supervisor would need to be assigned as an addition to the demonstration site personnel, but additional billets would not be needed because CNET could provide for the supervisor from its personnel allocation. While the supervisor would be available for normal demonstration duties, as time permits, it would seem more likely that the majority of his time would be consumed by demonstration duties.

It should be noted that one of the major functions of the learning supervisor would be to obtain information indicative of how the CMI system could be blended into the daily activities of the demonstration site, as well as how an operational site would organize its operations to manage the system. Further, it would be expected that the supervisor would work with the research team during the Evaluation Phase of the project.

(3) Maintenance Personnel

As was mentioned previously, it would be necessary for one maintenance person to be made available for preventive and corrective maintenance on the OpScan. In order to reduce the number of persons that a demonstration site would need to absorb, it would be desirable to have an ET or a comparable skilled rate provided by the site. Basic requirements include:

- Attending a 10-day OpScan maintenance course at a CONUS location

- Providing two hours a week of preventive and corrective maintenance as required
- Recording maintenance information on appropriate maintenance forms
- Providing services for a period of seven months--one month trial run, six months demonstration

b. Status

Discussions have been held with BUPERS 212 and the basic personnel requirements have been presented. The major area of concern expressed by BUPERS involves a site's ability to absorb the demonstration sample size, particularly if it would be a single rate, and the possible problem partially trained recruits might bring to an operational unit. However, the use of new personnel has not been determined to be an insurmountable problem. Nevertheless, no background information on how to proceed has been obtained, since BUPERS indicated a demonstration site must be identified before further action can be taken. It is anticipated that no problems like those mentioned above would be encountered if existing site personnel were used for the demonstration.

C. Summary

Of the five basic requirements, three have been thoroughly analyzed and checked with the potential contributors: a possible U.S. Navy communications system has been defined for the demonstration and tentatively approved by all individuals to be involved with the exception of the demonstration site commander; the use and function of the CMI computer facility has been defined and tentatively approved by NETISA; and the existing CMI courses have been analyzed for potential use in the demonstration and possible candidates identified If a non-existing course would be used, additional time and money would be required to operationalize it. In all of the above cases, official tasking would be required, and manpower and funds would need to be made available. The two requirements which have been analyzed but which have not been checked out in detail are the demonstration site and demonstration personnel. Both are interrelated; details on possible demonstration personnel cannot be worked out until a demonstration site has been identified.

The details relative to the demonstration requirements, conditions and constraints are provided in the following chapters.

Chapter III

ANALYSIS OF POSSIBLE DEMONSTRATION COMMUNICATIONS SYSTEMS

A. Introduction

This chapter describes the analysis performed in determining the preferred communications system to be used for the demonstration. This analysis included these parts:

- Calculation of data requirements in terms of the quantity of data to be transmitted from the ship to the CMI computer in Memphis and return, and the response time required.
- Analysis of the communications system alternatives considered.
- Evaluation of these alternatives in terms of performance provided and costs incurred for the demonstration, leading to a selection of the recommended system.

B. Data Requirements of the Demonstration System

This section describes the requirements to be met by the communications system during the demonstration,[1] including:

- The amount of data to be transmitted from the ship to the CMI computer.
- The amount of data to be transmitted from the CMI computer to the ship.
- The time response required for the two-way communication.

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[1] An estimate of the data requirements of the operational system is contained in Chapter IX.

1. Average Data Transmission Requirement for Each Type of Message

The following data represents current operating experience at the CMI computer center for all courses on line in July 1976.

a. CMI Message Sent (from student to CMI computer)

There were an average of 18,000 student inputs to the CMI computer per day. Since there were 3,000 students enrolled and each student studied six hours per day, this results in an average of one CMI message sent for each hour of training.

Based on the total data handled per unit time, the average CMI message sent for all CMI courses currently on line contains a total of 81 characters (including student and lesson identification).

b. CMI Message Reply (from CMI computer to student)

There is one reply for each message and, as stated previously, this occurs for each hour of student training.

The average CMI message reply contains a total of 1,600 characters (although a reply can be as large as 12,000 characters for the BT/MM course).

c. Administrative Message Reply (from CMI computer to learning supervisor)

In addition to the CMI message replies, there are a number of administrative messages currently sent to the learning supervisor in response to his query. While the final designation of which messages will be available to the learning supervisor during the demonstration and the specifications of the format of such messages will be made during the next phase, we have arrived at the following conclusions:

- The most important information for the learning supervisor to have is the names of all students who are lagging by more than a given amount of time behind where they should be in the course. This information can be obtained by combining the following factors:

- The predicted chronological milestones for successfully completing each test. This is obtained from the predictor algorithm based on the student's battery of recruit testing and the training schedule over time.
- The amount of time that will be allowed to pass beyond a milestone before a student will be classified as "deficient" and his name will be sent to the learning supervisor.

- Most of the rest of the administrative messages pertain to other matters and will probably not be needed during the demonstration.

2. CMI Message Batching and Formatting

Contact was made with COMNAVTELCOM to determine the standard Navy message form which each of these two types of CMI messages must follow. Table III-1 illustrates the format[1] of a student message from the ship (USS Kennedy, for example) to the CMI computer at Memphis, as provided by COMNAVTELCOM. This message consists of a 208-character header, message text which cannot exceed 40 lines, each containing about 62 characters, and a 59-character trailer. Since the average CMI message sent contains 81 characters, including identification of the student, course, and lesson, batching of student messages is required for efficient data transmission. In fact, the most efficient data transmission would be obtained by using a special end of message character printed on the OpScan sheets, running all CMI messages together into one large tape, and letting the NAVMACS[2] A-Plus computer on the ship divide the total message into separate segments of 40 lines each. Using an end of message character, the average CMI message sent would contain 82 characters. Based upon 62 characters per line and a maximum block of 40 lines of text, the number of CMI messages sent, N_s that could be batched in a single message is, on the average:

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[1] Since the message shown in Table III-1 is manually generated, no carriage return symbol is shown, as is the case for the computer generated message shown later.

[2] Navy Modular Automated Communications System.

$$N_s = \frac{62 \times 40}{81 + 1} = 30.2 \text{ CMI messages sent per Navy message sent}$$

Thus, the total data requirements of a Navy message containing 30 CMI messages sent in the text can be calculated as follows:

Header (see Table III-1)	208 characters
Text (30 x 82)	2,460 characters
Trailer (see Table III-1)	59 characters
Total	2,727 characters

Table III-1. NTCS Format of CMI Message Sent from Ship to CMI Computer, Memphis: Delivery in Tape-to-Card (Data Pattern Format) to NETISA Detachment, Memphis

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RTCUDAZZ RULYSAA1234 2081300 MTMS-UUUU-RUCIFMA.
ZNR UUUUU
R 061300Z OCT 76
FM USS JOHN F KENNEDY
TO RUCLFMA/NETISA DET NAVAL AIR STATION MEMPHIS TN
BT
UNCLAS //N01500//
COMISAT CMI STUDENT INSTRUCTION DATA
1. T E X T (40 lines maximum)
BT
#1234
RTCUDAZZ RULYSAA1234 2081300 MTMS-UUUU          NNNN
```

Based on an assumption of 30 students engaged in an average of two hours per day of training, the daily data requirements of the CMI messages sent would be two of the above messages, or 5,454 characters per day (sending 30 CMI messages in each batch). The communications efficiency (CE) of this process may be calculated as follows:

$$CE = \frac{\text{Text characters}}{\text{Total characters}} = \frac{2460}{2727} \times 100\% = 90.2\%^{1}$$

However, if there were only 20 CMI messages sent in the batch (and hence three messages sent per day), each message would contain:

Header	208 characters
Text (20 x 82)	1,640 characters
Trailer	59 characters
Total	1,907 characters

Thus, the total data requirements of the three messages would be 5,721 characters per day. The communications efficiency of this process would be: $\frac{1640}{1907} \times 100\% = 86.0\%$

Finally, if the CMI messages can be sent in batches of ten, each message would contain:

Header	208 characters
Text (10 x 82)	820 characters
Trailer	59 characters
Total	1,087 characters

The total data requirements of the six messages would be 6,522 characters per day, with a communications efficiency of:

$$\frac{820}{1,087} \times 100\% = 75.4\%$$

The data requirements of the reply messages can be calculated in the same way. The number of CMI message replies, N_r, that could be

---

[1] This assumes no retransmissions or service messages because of transmission errors.

batched depends on their length. If the length of the CMI message reply is 1,600 characters of text and one end-of-message character,

$$N_r = \frac{62 \text{ characters} \times 40 \text{ lines}}{(1{,}600 + 1) \text{ characters}} = 1.55 \text{ CMI message replies per Navy}$$

message reply.

Assuming that only one CMI message reply of 1,601 characters of text was sent, the total number of characters sent in each Navy message reply is:

Header (see Table III-2)	237 characters
Text (1,601)	1,601 characters
Trailer (see Table III-2)	54 characters
Total	1,892 characters

Table III-2. NTCS Format of Reply Message from CMI Computer to Ship: Originated in Card-to-Tape by NETISA Detachment, Memphis

```
RCTUDAZZ RULYSAA1234 2801300 0050-UUUU—RUISJFK <
ZNR UUUUU <
R 061300Z OCT 76 <
FM NETISA DET NAVAL AIR STATION  MEMPHIS TN <
TO USS JOHN F KENNEDY <
BT <
UNCLAS    //N01500// <
PASS TO COMISAT LEARNING  SUPERVISOR  <
COMISAT CMI STUDENT INSTRUCTION DATA <
1. T E X T  40  LINES BLOCK <
BT <
RCTUDAZZ RULYSAA1234 2801300 0050-UUUU        NNNN <
```

Note: < is the carriage return symbol

The communications efficiency of this process is:

$$\frac{1601}{1892} \times 100\% = 84.6\%$$

Based on an assumption of 60 of these CMI message replies being sent each day, the daily data requirements of these 60 Navy message replies would be: (60)(1,892) = 113,520 characters per day. Thus, the total daily data requirements for the demonstration would be 118,974 characters for all messages sent and replied.

For greater communications efficiency, it should be possible to transmit a batch of CMI message replies in which the text of any CMI message reply which extends beyond the 40th line would continue on the next Navy message reply. In this case, all but the last Navy reply message would have the following characteristics:

Header	237 characters
Text (62 x 40)	2,480 characters
Trailer	54 characters
Total	2,771 characters

$$\text{Communications efficiency} = \frac{2480}{2771} \times 100\% = 89.5\%$$

In this case, the total number of characters in the Navy message replies sent each day is approximately:[1]

$$\frac{(60)(1,601)}{.895} = 107,330 \text{ characters}$$

which would result in a total daily data requirement over the satellite for the demonstration ranging between 112,784 and 113,852 characters per day. This corresponds to between 94 and 95 average 1,200-character Navy messages to be transmitted each day.

---

[1] This ignores the lower efficiency of the final message in each batch of reply messages transmitted each day. The actual total is 107,409 characters for the 39 Navy message replies.

Periodically, the Learning Supervisor (LS) will request some administrative reports such as the complete progress of a student. Such reports are currently printed on the Administrative Terminal for the LS.

Our review of the current system shows that:

- Such reports are very lengthy.
- "Management by exception" reporting would provide the LS with information on those students needing his attention with much less data transmission.

Since the data transmission using the satellite must be minimized, we plan the following actions:

- During the demonstration, all administrative reports will be transmitted to the LS by mail, unless we find during the Design Phase that the size of these messages is small. The effect of this delay on student management will be measured.
- The operational system will be designed to provide management by exception reporting.

Hence, the requirement for LS replies via satellite during the demonstration will either be zero or negligible.

3. Calculation of Response Time Required

The most important characteristic which determines the response time which the communications system must meet is the time between when the student's test is submitted for scoring and when his schedule calls for his continuing with the next lesson. Several scenarios described below will illustrate this relationship.

Figure III-1A illustrates the time sequence of events in the day of a student training in a CONUS schoolhouse. He studies the training material and once each hour, on the average, he takes a test. The test is then inserted in the OpScan 17 terminal for scoring and feedback (indicating that he advances to the next module or remediates as shown). Since this process keeps repeating over the six- or eight-hour day, any

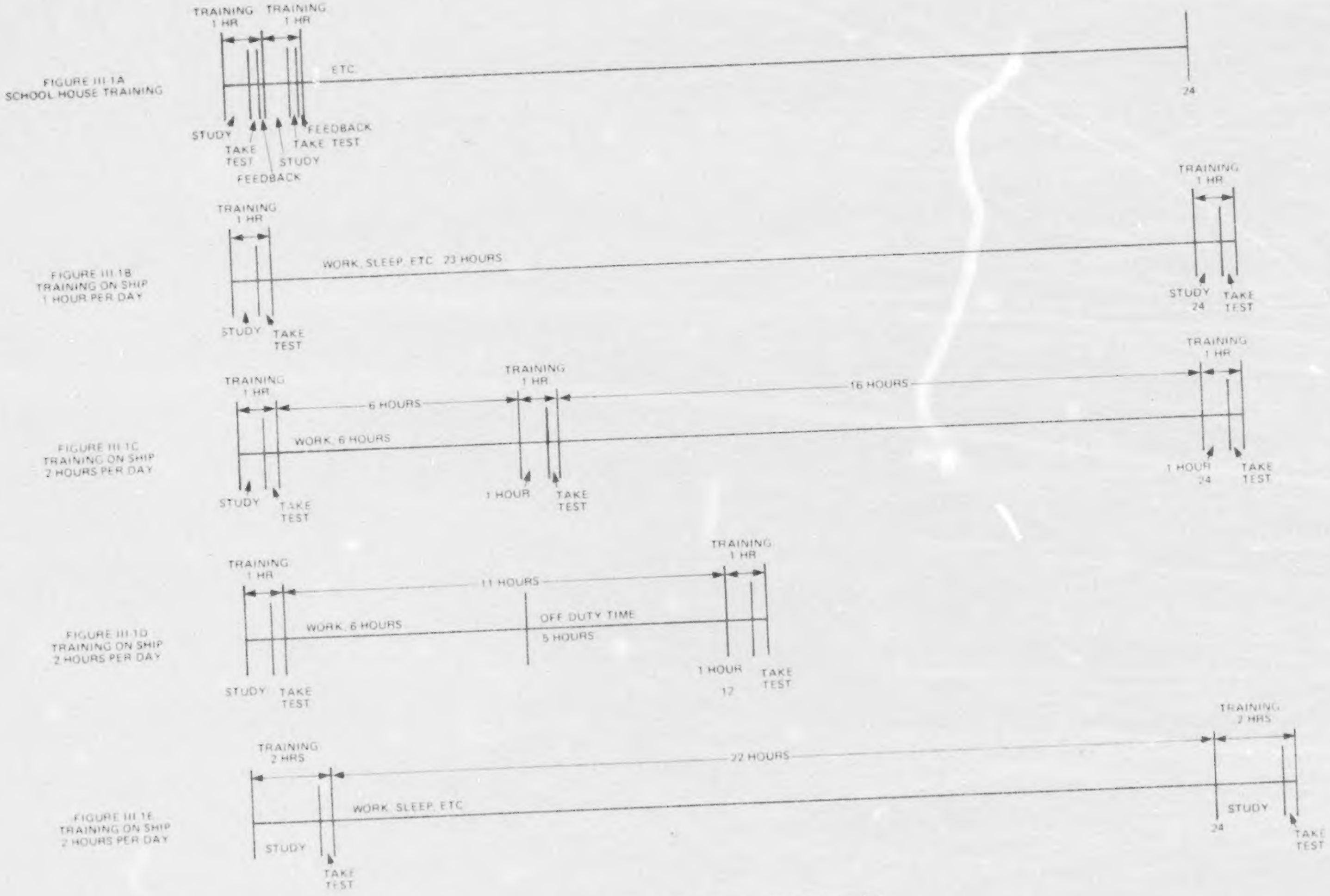


FIGURE III-1A
SCHOOL HOUSE TRAINING
TRAINING 1 HR
TRAINING 1 HR
ETC.
24
STUDY
TAKE TEST
FEEDBACK
STUDY
TAKE TEST
FEEDBACK
FIGURE III-1B
TRAINING ON SHIP
1 HOUR PER DAY
TRAINING 1 HR
WORK, SLEEP, ETC. 23 HOURS
STUDY
TAKE TEST
TRAINING 1 HR
STUDY
24
TAKE TEST
FIGURE III-1C
TRAINING ON SHIP
2 HOURS PER DAY
TRAINING 1 HR
6 HOURS
TRAINING 1 HR
16 HOURS
TRAINING 1 HR
WORK, 6 HOURS
STUDY
TAKE TEST
1 HOUR
TAKE TEST
1 HOUR
24
TAKE TEST
FIGURE III-1D
TRAINING ON SHIP
2 HOURS PER DAY
TRAINING 1 HR
11 HOURS
TRAINING 1 HR
WORK, 6 HOURS
OFF DUTY TIME
5 HOURS
STUDY
TAKE TEST
1 HOUR
12
TAKE TEST
FIGURE III-1E
TRAINING ON SHIP
2 HOURS PER DAY
TRAINING 2 HRS
22 HOURS
TRAINING 2 HRS
WORK, SLEEP, ETC.
STUDY
TAKE TEST
STUDY
24
TAKE TEST

Figure III-1. Time Sequence of Training and Work Activities

delay in obtaining the feedback message is time completely lost to the student (since he normally has nothing else to do while waiting for the feedback).

Figure III-1B illustrates the day's activities of a student training for one hour per day on a ship. Assuming that he takes the test toward the end of the training hour, he must have the test results returned to him within 23 hours. Thus, the maximum total response time is 23 hours, including the time lost due to "batching," waiting for a number of tests to be collected prior to transmission.

Figure III-1C illustrates a more difficult scenario, in which two hours of instruction per day are allowed, and programmed as the first hour and last hour of an eight-hour work shift. Thus, the intervening time of six hours in one case and 16 hours in the other is available for obtaining feedback on the test.

If the six-hour response time is not long enough (the demonstration will be used to determine this), these other possibilities are available:

- Figure III-1D illustrates that the average of 11 hours of response time could be achieved by delaying the start of the second hour of training five hours by doing some other activity, such as eating, during this time.
- Figure III-1E is another scenario in which modules are divided into two hours of length for one test so that the test results are not required for 22 hours.

If the scenario of Figure III-1C (the worst case, requiring a six-hour response time) is imposed, there are two possibilities for meeting this:

- Construct the course so that the student takes two-hour modules and hence the scenario is converted to Figure III-1E.
- Construct the course in two parallel, but not closely related, tracks. The student takes a one-hour module from one track,

then a one-hour module from the second track. Alternating modules effectively changes the scenario to Figure III-1A for each track, thus permitting a time response of 23 hours for each track.

C. Analysis of the Communications System Alternatives

1. Structure of the Functional Analysis

To make certain that all feasible communications systems alternatives were identified and evaluated, the total information delivery system was defined as consisting of three major parts, as shown in Figure III-2.

- F_2 consisting of all ship-to-shore and shore-to-ship communications alternatives available. These include:
  - -- Navy communications system, in which the GapSat satellite plays the major role
  - -- NASA ATS-1 or 3
  - -- NASA ATS-6
  - -- COMSAT General
  - -- High Frequency (HF) and AUTODIN (for ships)
  - -- Defense Communications System and AUTODIN (for remote land sites)

- F_1, consisting of all ways of interfacing the ship with F_2. Thus, the ship-to-shore interface of F_1 consists of all equipment we must add to insert a CMI test message into F_2; while the shore-to-ship interfaces (called F_1') consist of all equipment we must add to convert the signal output from F_2 into a readable CMI reply message.

- F_3, consisting of ways of interfacing F_2 with the CMI computer. Thus, the ship-to-shore interface of F_3 consists of all equipment we must add to transport the signal output of F_2 to the CMI computer in Memphis and convert it into a form which can be accepted for processing by the computer. Conversely, the shore-to-ship interface (called F_3') consists of all equipment we must add to transport the signal output of the computer to F_2 and convert it into a form which can be accepted by F_2.

Having described the structure of the functional analysis performed, the analysis of the options will now be presented.

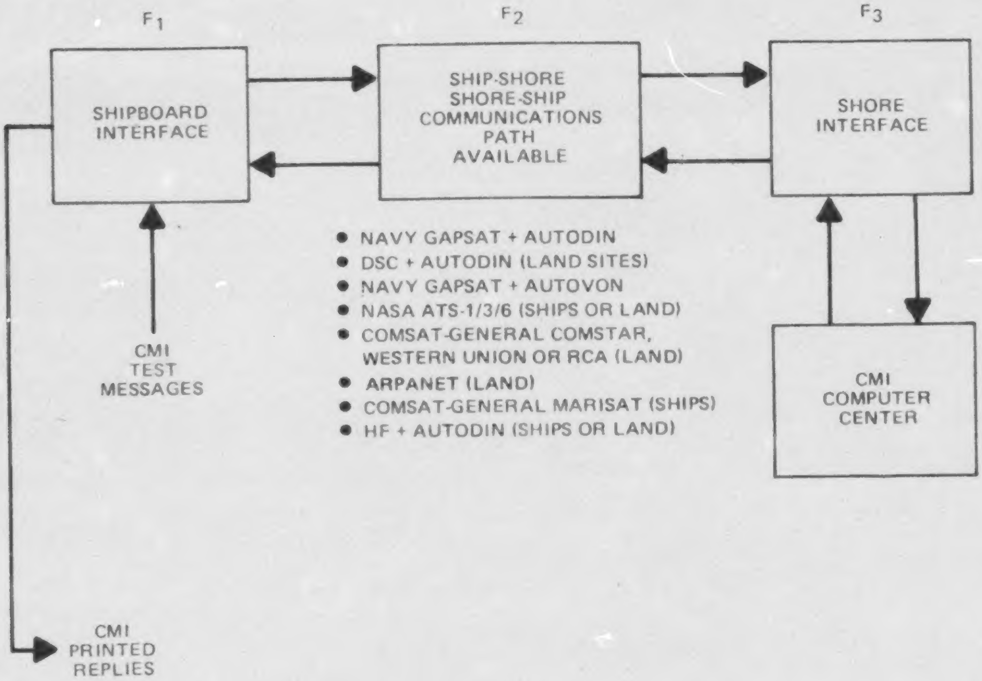

F1
F2
F3
SHIPBOARD INTERFACE
SHIP-SHORE SHORE-SHIP COMMUNICATIONS PATH AVAILABLE
SHORE INTERFACE
CMI TEST MESSAGES
CMI COMPUTER CENTER
CMI PRINTED REPLIES
● NAVY GAPSAT + AUTODIN
● DSC + AUTODIN (LAND SITES)
● NAVY GAPSAT + AUTOVON
● NASA ATS-1/3/6 (SHIPS OR LAND)
● COMSAT-GENERAL COMSTAR, WESTERN UNION OR RCA (LAND)
● ARPANET (LAND)
● COMSAT-GENERAL MARISAT (SHIPS)
● HF + AUTODIN (SHIPS OR LAND)

Figure III-2. Communications System Alternatives

2. Navy Communications System Options

Two fundamentally different communications system design concepts were identified and analyzed using the standard Navy communications system. The first concept, which is the one recommended for the demonstration, uses the standard Navy message system, in which the CMI message is converted into a standard Navy message, inserted into the Navy Modular Automated Communications System (NAVMACS) A-Plus, transmitted to the ship's appropriate Naval Communications Area Master Station (NAVCAMS) fleet center (at Honolulu for the East Pacific, Guam for the West Pacific, or Norfolk for the Atlantic) via Gapfiller, to the Memphis NAS TCC via AUTODIN and then to the Memphis CMI computer, and return.

A second concept analyzed uses the standard Navy voice circuits, in which the CMI message is converted into a series of coded tones and transmitted to the NAVCAMS fleet center via a Gapfiller voice channel.

At this point, it is routed to the CMI computer through one of several combinations of voice channel paths, including AUTOVON, the ARPANET, dedicated lines, or commercial telephone circuits. The return path uses essentially the same mode of operation. Using this communications system, which is essentially telephone circuits, is more compatible with the current CMI system because of the coding used. The current CMI system uses the OpScan equipment to translate the CMI message into a code called "ASCII," and the entire system transmits and processes all information, keeping it in this code until the Terminet translates the reply into English. If the Navy voice circuits were used, we would continue to use the same approach since the voice circuit does not distinguish what type of information passes through it. However, if the Navy Message System is used, a different coding system called the "Baudot" code must be used. Hence, some coding translations will have to be done, as described later. This system is more compatible with the CMI computer since the messages can remain in ASCII code, unlike the first concept.

Each of the two basic Navy communications system options examined will now be described, including:

- The various functions to be performed by each system option.
- How each function might be implemented (including which standard Navy equipment will be available for use, and which equipment will have to be procured solely for this demonstration).
- Any Navy constraints which will have to be observed.
- An evaluation of the alternative design configurations, including the recommended design.
- A summary of the resources required to procure, operate, and maintain the recommended system.

a. Option 1--Navy Telecommunications System

(1) Using Navy Message Telecommunications System

Figure III-3 is a flow diagram showing the flow of data from the ship to the CMI computer and return using the standard Navy

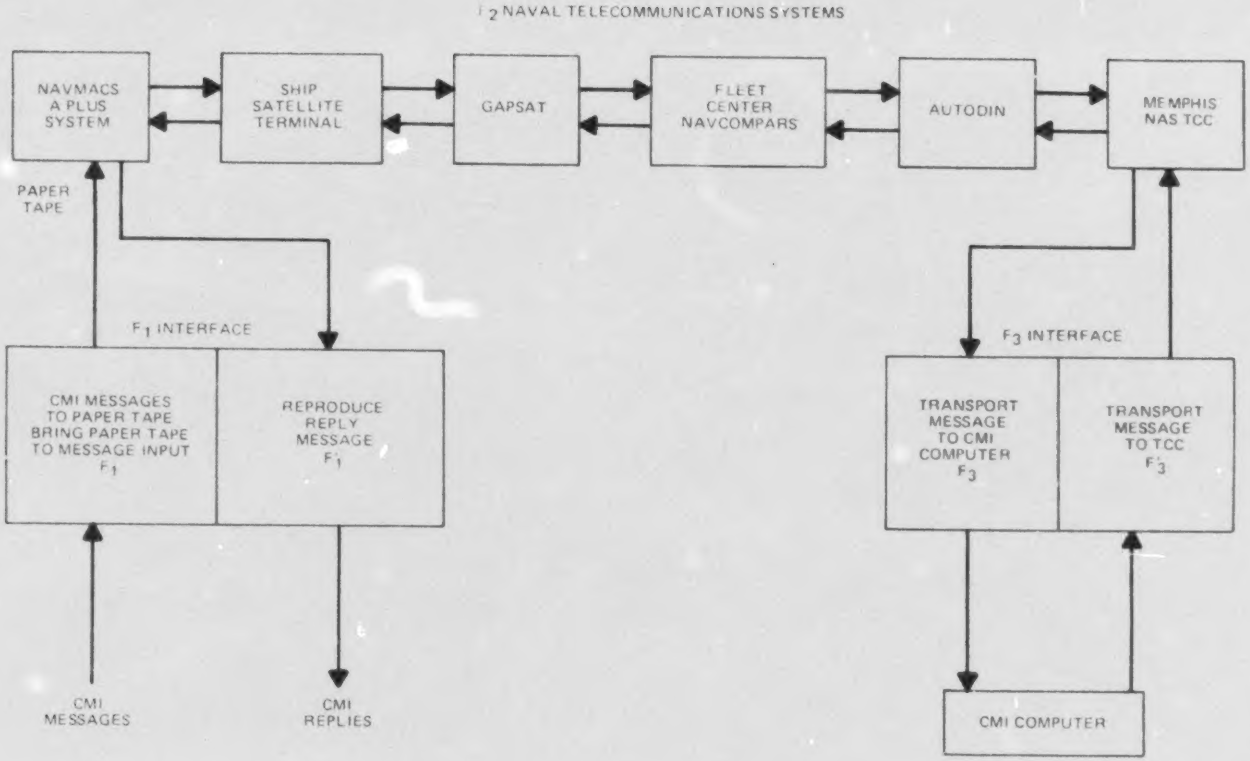

F2 NAVAL TELECOMMUNICATIONS SYSTEMS
NAVMACS A PLUS SYSTEM
SHIP SATELLITE TERMINAL
GAPSAT
FLEET CENTER NAVCOMPARS
AUTODIN
MEMPHIS NAS TCC
PAPER TAPE
F1 INTERFACE
CMI MESSAGES TO PAPER TAPE BRING PAPER TAPE TO MESSAGE INPUT F1
REPRODUCE REPLY MESSAGE F'1
CMI MESSAGES
CMI REPLIES
F3 INTERFACE
TRANSPORT MESSAGE TO CMI COMPUTER F3
TRANSPORT MESSAGE TO TCC F'3
CMI COMPUTER

Figure III-3. Naval Message System Design

message distribution system. The three major functions involved in transmitting the CMI messages from the ship to the CMI computer are:

- F_2 is the standard Navy telecommunications system which can transmit a Naval message from the ship to the Memphis NAS TCC, resulting in a magnetic or paper tape output.
- F_1 is the function which converts the set of CMI messages into paper tape (the only message input which the NAVMACS A-Plus system will accept) and transports it to the ship's telecommunications center (TCC).
- F_3 is the function of transporting the tape to the CMI computer.

In addition, there are three major functions involved in transmitting CMI reply messages from the CMI computer to the ship over this path:

- F_2' is the standard Navy telecommunications system which transmits the message from the Memphis NAS TCC to the ship's TCC.
- F_1' is the function which converts the set of reply messages from the computer to the Memphis NAS TCC.
- F_3' is the function of transporting the reply messages to the students or instructor.

Each of these functions will now be described indicating the various design options available for implementation. The current Navy telecommunications system, or F_2, is discussed first.

(a) F_2: Navy Telecommunications System

F_2 is described first since it is the given element with which F_1 and F_3, of numerous variations, must interface. Alternative ways by which these functions can interface with F_2 will be described next.

The current Navy system accepts a message in hard copy form at the ship's TCC and logs it in. A radioman, using a teletype, converts this message into paper tape form (the only form in which the NAVMACS A-Plus will accept messages), including a message header containing the routing indicator and date/time group, and a message trailer following the text.

A radioman then feeds the paper tape into the NAVMACS where it is stored in the AN/UYK-20 computer and placed in line to await transmission in accordance with its precedence. If the total message is longer than the maximum of 40 lines permitted, the message is automatically dissected into several sections and the same header used for each. After the message reaches the head of its line, it is transmitted via the Gapfiller satellite to the fleet center designated for the particular communications area in which the ship is located. In the East Pacific, this is NAVCAMS (Navy Communications Area Master Station) Honolulu. In the Atlantic, it is NAVCAMS Norfolk. The message then proceeds over the AUTODIN system and is automatically routed to the Memphis NAS TCC as addressed.

At the Memphis NAS TCC, the digital message is automatically decrypted and converted into either of three possible output forms as previously specified in the message heading:

- Paper tape
- Punched cards
- Magnetic tape[1]

Each of the other two system functions (F_1 and F_3) will now be described.

---

[1] It should be noted that currently the Memphis TCC can only provide a paper tape output.

(b) F_1: CMI Message Input to NAVMACS

The object of function F_1 is to convert the information on the CMI message into paper tape form, suitable for entry into NAVMACS, and transport the tape to the ship's TCC.

There are two types of CMI messages which will be transmitted from the ship to shore:

- The first is called a Student Message and consists of a student test to be evaluated by the computer. Here, the student completes his day's study and meets with the Learning Supervisor (LS) (on appointment) at the learning center. There the student takes and receives his test on an OpScan 17 test form provided by the instructor. This procedure avoids any collusion and gives the student an opportunity to see the instructor for any last minute aid. To minimize student errors, each student is given a test paper which has been pre-marked with his identification number (social security number and any other designator desired for error checks). The average data content of a student message is 81 characters. Currently, a student message occurs once per student hour of instruction.
- The second type message is called a Learning Supervisor Message. If the LS desires a management report from the computer, he designates this request on his OpScan message form, especially designed for him to indicate which management report he desires the computer to send him.

Since the Navy message header containing the routing indicator and trailer require 267 characters, communication efficiency is increased by batching together as many CMI messages to the Memphis computer as is possible. However, we must also consider the maximum delay time which the educational process can tolerate (to be determined by the demonstration). This may dictate that the CMI messages should be sent more often than once a day. It would seem that an LS Message could be batched with Student Messages since each message has a separate identifier, and the computer could separate the two types of messages on that basis. Obviously, if for some (unlikely) reason the supervisor needs faster response for a request, he would not use batching.

Five design alternatives for implementing F_1 are shown in Figure III-4:

(i) Alternative F_{11}

This alternative consists of the student inserting his completed test paper into a CMI "mailbox," locked to preserve privacy, and holding all messages to be transmitted at the next scheduled time. The first step in the transmission process is to check the operability of the encoding equipment (the OpScan 17 and the UGC-6 teletype). To do this the LS stacks a set of specially prepared test messages into the OpScan 17, which is connected to a UGC-6 teletype with paper tape punch. This results in the generation of one paper tape which contains the entire set of test messages in teletype coded form. The UGC-6 also provides a printed output of the test messages, permitting the LS to perform a total system check of both the OpScan 17 and the teletype by verifying the hard copy of the test messages. He can even check the first few symbols of the paper tape to see if this was punched properly. After this system check, the LS stacks the real set of messages to be transmitted onto the OpScan 17 and repeats the process, obtaining the true message tape.

Three methods of obtaining the message header for the CMI textual messages were developed and reviewed with officers at the COMNAVTELCOM:

- The preferred way is for the LS to bring the tape and a signed, preprinted cover sheet (Figure III-5) to the ship's TCC and let the message be handled by the Radioman as he would an ordinary message. He would log it in, type the message header, and then insert the text tape in the UGC-6 teletype reader which would automatically create the addition to the message tape. The RM then types in the message trailer. CNTC estimated that this would require only 1 to 1-1/2 minutes of operator typing, and for one to two messages per day would be a negligible load on the Radioman. The fact that we would provide the punched textual tape would save major time.

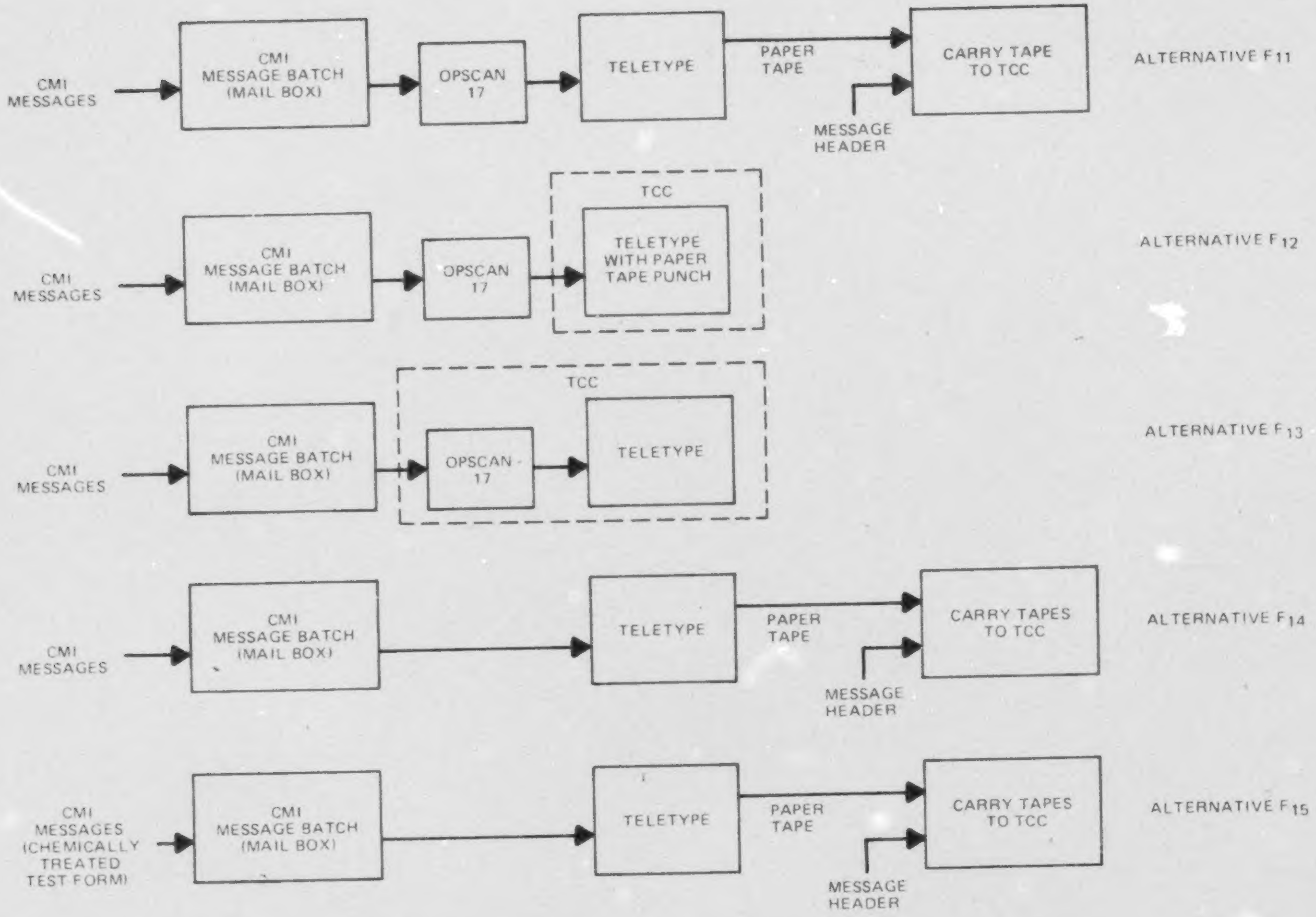
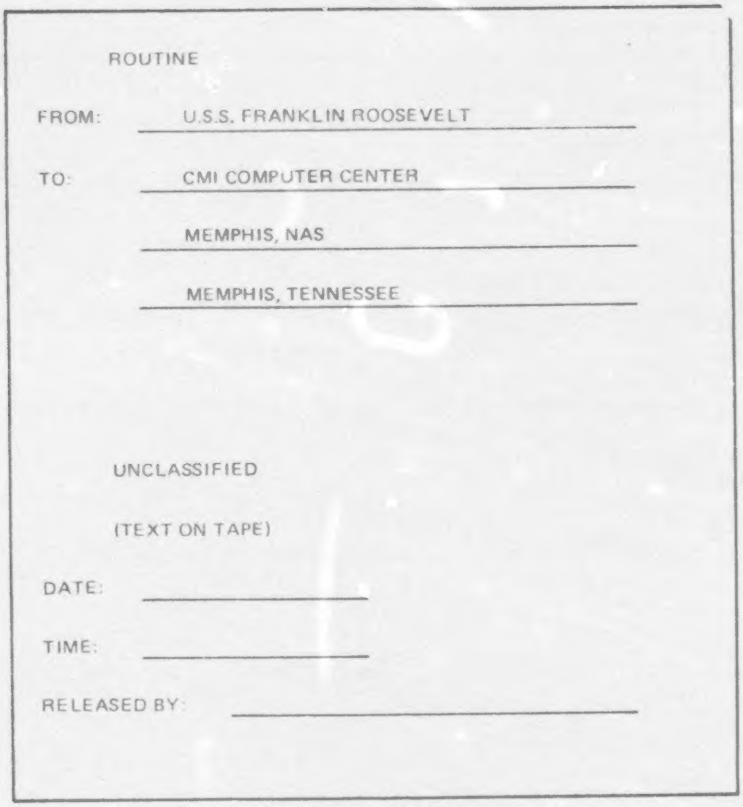

CMI MESSAGES
CMI MESSAGE BATCH (MAIL BOX)
OPSCAN 17
TELETYPE
PAPER TAPE
CARRY TAPE TO TCC
MESSAGE HEADER
ALTERNATIVE F11
CMI MESSAGES
CMI MESSAGE BATCH (MAIL BOX)
OPSCAN 17
TCC
TELETYPE WITH PAPER TAPE PUNCH
ALTERNATIVE F12
CMI MESSAGES
CMI MESSAGE BATCH (MAIL BOX)
TCC
OPSCAN 17
TELETYPE
ALTERNATIVE F13
CMI MESSAGES
CMI MESSAGE BATCH (MAIL BOX)
TELETYPE
PAPER TAPE
CARRY TAPES TO TCC
MESSAGE HEADER
ALTERNATIVE F14
CMI MESSAGES (CHEMICALLY TREATED TEST FORM)
CMI MESSAGE BATCH (MAIL BOX)
TELETYPE
PAPER TAPE
CARRY TAPES TO TCC
MESSAGE HEADER
ALTERNATIVE F15

Figure III-4. CMI Message Conversion and Transport to Ship's Message Center (F_1)



ROUTINE

FROM: U.S.S. FRANKLIN ROOSEVELT

TO: CMI COMPUTER CENTER
MEMPHIS, NAS
MEMPHIS, TENNESSEE

UNCLASSIFIED

(TEXT ON TAPE)

DATE: ____________

TIME: ____________

RELEASED BY: ____________________

Figure III-5. Message Release Form

- The second alternative is to have the LS compose the header himself. This is certainly feasible using his UGC-6 as follows: All of the preformatted message heading information such as routing indicator, precedence, from line, Plain Language Address Designator/Identifier, Standard Subject Identification Code, etc., could be prepunched onto a mylar tape. The tape could then be notched at one edge at the place where the non-standard information, such as date/time group and serial number (a pre-assigned block of numbers would be given to the LS) is to be inserted. Thus, the LS would insert the mylar tape into the tape reader portion of the UGC-6, causing it to punch a new paper tape containing the preformatted information. The process would then stop at the first notch. The LS would then turn the T/D[1] switch to OFF, move one space, and type in the unique information. He would then turn the T/D switch to ON and continue the process. The tape would stop for the text message, at which time the LS would start the OpScan 17 which would again activate the teletype. In this way, a complete paper tape could be generated. The LS would again fill out the message cover sheet and deposit both at the TCC.

---

[1] T/D stands for Transmitter Distributor Switch, the tape reader.

Incidentally, CNTC has run mylar tape in an endless loop, and found that it has lasted for three months. Hence, one mylar tape would probably last for the entire demonstration.

The main reason this alternative was not preferred by CNTC was the possibility of the LS making an error, thus requiring a service message. They felt that the slight extra work for the Radioman was not worth the risk.

- The third alternative considered was to give the mylar tape to the Radioman and thus cut down on his work. Here the problem was to keep track of all the preformatted tapes in the TCC. They felt it would be easier to type the entire header in each time than to have to retrieve the mylar tape and work from that.

In conclusion, it was agreed that all three alternatives are feasible and the final decision should be made by the ship's Communications Officer.

It should be noted that the OpScan 17 and the teletype must operate at the same speed. The former can operate at 110, 300, 600, 1,200, 1,800 or 2,400 baud, or 75 baud on special order. The NAVMACS system will use any of these tape outputs since its tape reader is an optical head which counts the holes, irrespective of its reading speed. For reliability considerations, the OpScan 17 must be located in an air-conditioned room.

(ii) Alternative F_{12}

This consists of the same approach as Alternative F_{11}, except that the OpScan 17 is connected to a teletype located in the ship's TCC through a secure, shielded wire (to comply with Tempest Clearance security). The teletype does not always have to be connected to the OpScan 17; the LS can call the message center and request that the OpScan wire be connected to a spare teletype for transmission of his batch of messages. After the system is tested, the CMI messages are transmitted to this teletype and the paper tape generated. Then the Radioman generates the header tape and the date/time group, as described before, and inserts the total message into the communications system. The main disadvantage of this alternative is that the LS needs a Radioman to assist him during the operation, since two locations are involved.

(iii) Alternative F_{13}

This is the same as Alternative F_{11}, except that both the OpScan 17 and the teletype would be located inside the communications room, assuming space is available. This satisfies the requirement of the air-conditioned space and also may eliminate the need for an extra teletype unit since a spare teletype located in this room would satisfy the short time use required. Having both units of equipment in the same room would permit the LS to operate the system in the same way as described under Alternative F_{11}.[1]

Two other F_1 alternatives were also designed, not as serious competing alternatives to the three described, but really as back-up alternatives if the OpScan 17 fails and cannot be repaired in time.

(iv) Alternative F_{14}

Because of possible reliability problems with the OpScan 17, the data on the test papers could be manually converted to paper tape by operating a teletype. Here the LS would type the identification number and test answers of each student using the UGC-6 teletype which has a monitor roll for reading the answers and thus verifying the typing accuracy. Again, the teletype could be located either outside the communications room, or in the communications room.

---

[1] If the LS is not permitted in the communications room, the radioman would have to operate the system under this alternative.

(v) Alternative F_{15}

In this alternative a chemically treated paper is used by the student to record his answers. This is especially constructed to give immediate feedback of the test results to the student. The main benefit of this alternative is that the message would consist of information on only those questions which are incorrect, thereby saving on the quantities of communications sent and reducing transmission errors.

An evaluation of these F_1 design alternatives was made and F_{13} selected as the preferred alternative. The rationale for this choice is given in the section on Evaluation of Alternatives.

(c) F_3: Getting Navy Message from AUTODIN to CMI Computer

As the CMI message leaves the ship, it travels over GapSat to shore where the AUTODIN system routes the message to the Memphis NAS TCC. Here the message is automatically decrypted, converted back to the alphanumeric code and transported to the CMI computer in one of six possible ways considered, as graphically depicted in Figure III-6.

(i) Alternative F_{31}

The first alternative considered uses the standard Navy delivery system for handling data messages. The decrypted message is routed from the AUTODIN switch at Albany, Georgia, to the Memphis NAS TCC, located less than one mile away from the CMI computer, where it is automatically decrypted and recorded on tape as specified in the message header. In Alternative F_{31}, it is punched out on paper tape, since that is the only data output the message center can provide

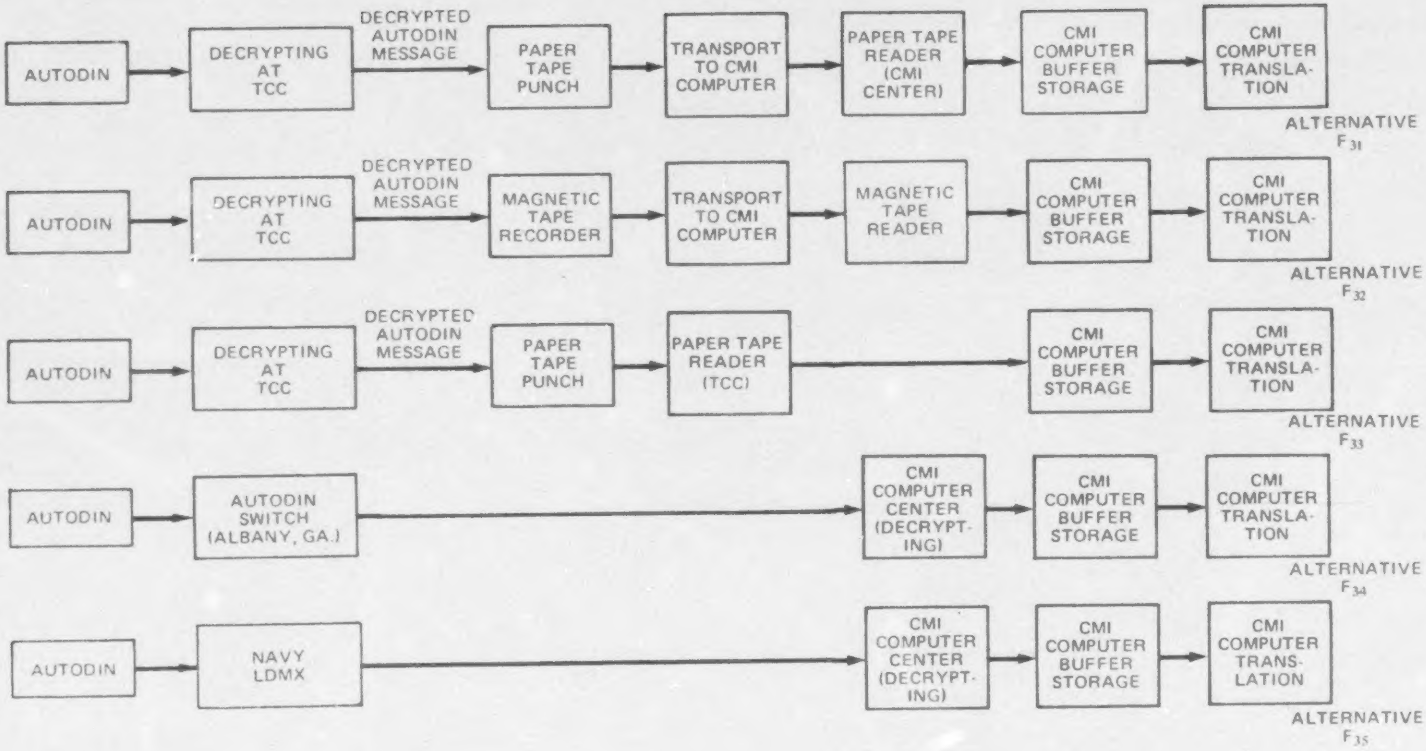

AUTODIN
DECRYPTING AT TCC
DECRYPTED AUTODIN MESSAGE
PAPER TAPE PUNCH
TRANSPORT TO CMI COMPUTER
PAPER TAPE READER (CMI CENTER)
CMI COMPUTER BUFFER STORAGE
CMI COMPUTER TRANSLATION
ALTERNATIVE F31
AUTODIN
DECRYPTING AT TCC
DECRYPTED AUTODIN MESSAGE
MAGNETIC TAPE RECORDER
TRANSPORT TO CMI COMPUTER
MAGNETIC TAPE READER
CMI COMPUTER BUFFER STORAGE
CMI COMPUTER TRANSLATION
ALTERNATIVE F32
AUTODIN
DECRYPTING AT TCC
DECRYPTED AUTODIN MESSAGE
PAPER TAPE PUNCH
PAPER TAPE READER (TCC)
CMI COMPUTER BUFFER STORAGE
CMI COMPUTER TRANSLATION
ALTERNATIVE F33
AUTODIN
AUTODIN SWITCH (ALBANY, GA.)
CMI COMPUTER CENTER (DECRYPTING)
CMI COMPUTER BUFFER STORAGE
CMI COMPUTER TRANSLATION
ALTERNATIVE F34
AUTODIN
NAVY LDMX
CMI COMPUTER CENTER (DECRYPTING)
CMI COMPUTER BUFFER STORAGE
CMI COMPUTER TRANSLATION
ALTERNATIVE F35

Figure III-6. CMI Message Transfer from AUTODIN to CMI Computer (Alternative F_3)

currently. The CMI computer center is notified by telephone that the ship's message tape is available; the center picks up both the tape and the hard copy and delivers them to the center where a check of the hard copy is made for any unauthorized characters. Following verification, the data are placed on a paper tape reader and read into the buffer storage (a Honeywell 6000 disk pack, presumably available). The data then enter the CMI computer and are translated from Baudot teletype code to the original CMI ASCII data format.

This alternative would require:

- A paper tape reader at the computer center.
- Buffer storage, if the DataNet now at Memphis cannot be used.
- Computer software to translate the teletype signal to the ASCII code for which the CMI computer is programmed.

Discussions with NETISA indicate this code translation is not a problem. They said that the Navy Maintenance Support Office and Ships Control Center at Mechanicsburg, Pennsylvania, and the Aviation Supply Office receive maintenance information in this way through AUTODIN, and hence the same translation approach might be applied here. Alternatively, it has been estimated that a microprocessor could be designed to perform this Baudot to ASCII translation for under $1,000.

(ii) Alternative F_{32}

This alternative is exactly like Alternative F_{31}, except magnetic tape is used instead of paper tape. While this offers the advantage of using the computer center's magnetic tape read-out device, the TCC would need a magnetic tape recorder, since it currently does not possess one. Since the TCC indicated that they would not have any other use for this type recorder, that it would be expensive and they would have a maintenance problem with it, this alternative was considered inferior to F_{31}.

(iii) Alternative F_{33}

This alternative is exactly like Alternative F_{31} except the function of transporting the message to the computer center is automated by having a TCC operator insert the paper tape into a paper tape reader which is connected by phone lines to the CMI center buffer store. This alternative would require:

- A paper tape reader at the TCC
- A dedicated land line to the center

While we thought that special security safeguards might have to be satisfied in constructing the wire link to the computer center, even though the CMI message is unclassified, our information indicates this would not be a problem if only unclassified messages were transmitted to the computer center. Also, since their paper tape reader (a standard Western Union Model 28) is not constantly in use, this reader could be used instead of a separate reader by having Western Union disconnect the reader from the AUTODIN line and replace the connection with a patch circuit. Thus, the reader would normally be connected to AUTODIN. However, when a CMI message to the computer center comes in, the tape reader could be switched to the land line going to the center, the tape read in (taking an average of one minute), and the reader then reconnected to the AUTODIN line.

(iv) Alternative F_{34}

This alternative essentially establishes the CMI computer center as a TCC, completely bypassing the Memphis TCC. This is done by running a land line from the nearest AUTODIN switch (Albany, Georgia) directly to the CMI computer center, establishing a new AUTODIN address and routing indicator. The AUTODIN signal then goes directly to the CMI Center where it is automatically decrypted and stored in buffer storage, as previously described.

(v) Alternative F_{35}

This alternative is like Alternative F_{34}, except that it connects the CMI computer center by land line with the nearest Navy LDMX (Local Digital Message Exchange) instead of the AUTODIN switch, thus saving some cost of the land line, and perhaps AUTODIN overhead costs.

An evaluation of these F_3 design alternatives was made and F_{31} selected as the preferred alternative for the demonstration, with F_{33}, using its own paper tape reader, the preferred alternative for the operational system. The rationale for this choice is given in the later section on Evaluation of Alternatives.

(d) F_2': Return Communications Path

After the different CMI messages are processed by the Memphis computer, the reply for each CMI message is stored in buffer storage so that one Navy message consisting of the set of narrative replies is automatically sent by the CMI computer to the ship over the reverse path shown in Figure III-7. Again, the three subsystems of F_1, F_2, and F_3 are involved, but in this case we define the return path functions as F_3', F_2', and F_1':

- F_3' passes the Navy narrative reply message from the CMI computer to the Memphis NAS TCC and into the AUTODIN system.
- F_2' passes the Navy message through the entire Navy message communications system (as before, through AUTODIN to the appropriate Fleet Center through a GapSat full period termination channel[1] to the ship's TCC).
- F_1' converts the narrative batch message into separate CMI messages, each addressed to the originating student, then reproduces and distributes the individual messages.

---

[1] CNTC recommends that our CMI messages from Memphis to the ship go via full period termination rather than via the fleet broadcast channels since they feel the time delay may be excessive using the latter. Permission for this negligible load will have to be requested from CNTC.

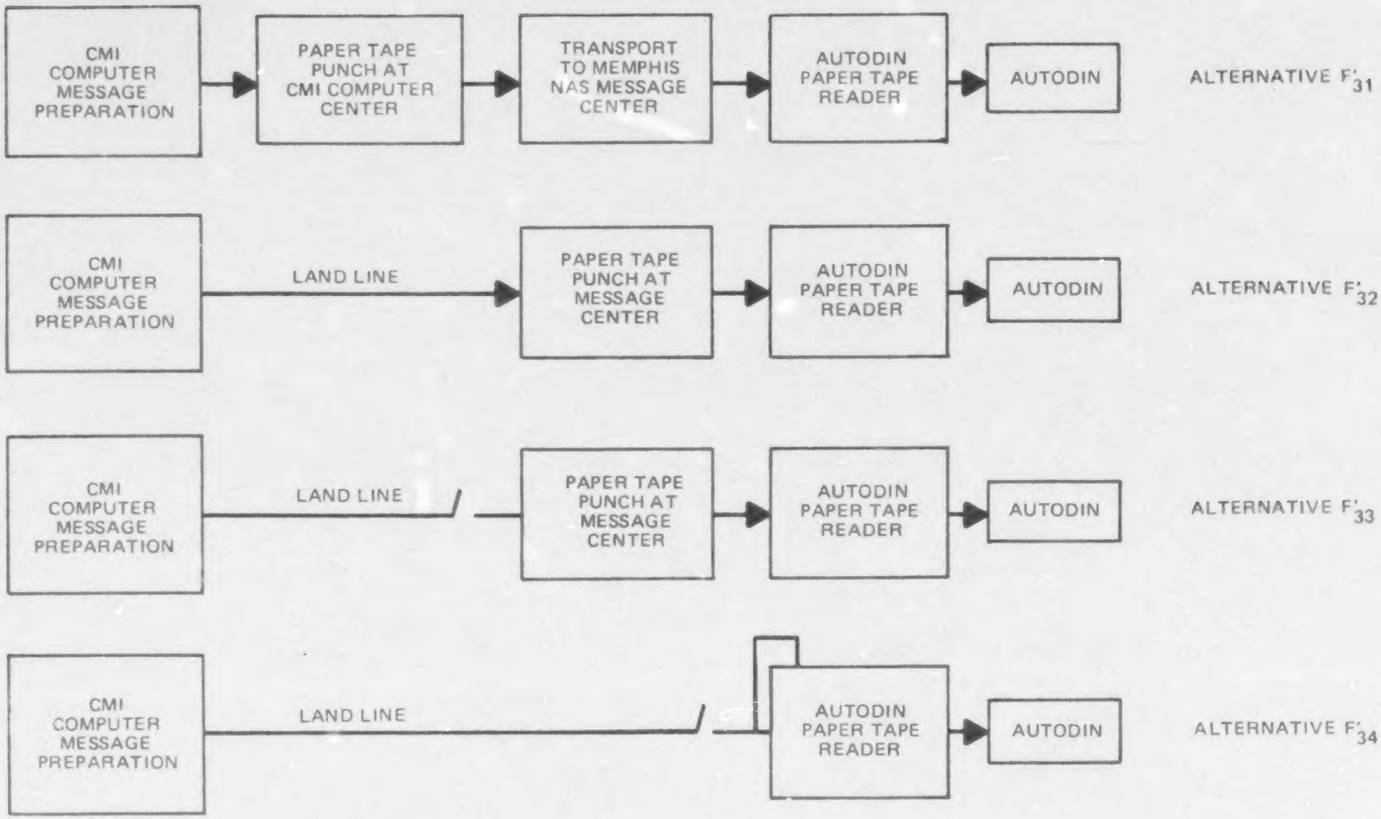

CMI COMPUTER MESSAGE PREPARATION
PAPER TAPE PUNCH AT CMI COMPUTER CENTER
TRANSPORT TO MEMPHIS NAS MESSAGE CENTER
AUTODIN PAPER TAPE READER
AUTODIN
ALTERNATIVE F'$_{31}$
CMI COMPUTER MESSAGE PREPARATION
LAND LINE
PAPER TAPE PUNCH AT MESSAGE CENTER
AUTODIN PAPER TAPE READER
AUTODIN
ALTERNATIVE F'$_{32}$
CMI COMPUTER MESSAGE PREPARATION
LAND LINE
PAPER TAPE PUNCH AT MESSAGE CENTER
AUTODIN PAPER TAPE READER
AUTODIN
ALTERNATIVE F'$_{33}$
CMI COMPUTER MESSAGE PREPARATION
LAND LINE
AUTODIN PAPER TAPE READER
AUTODIN
ALTERNATIVE F'$_{34}$

Figure III-7. CMI Message Transfer from CMI Computer to AUTODIN (F'$_3$)

Since F'_2 is the standard Navy message system and operates essentially as previously described, no further description will be given.

(e) F'_3: Getting the Message from the CMI Computer to AUTODIN

Four alternatives were considered for this function, as illustrated in Figure III-7.

(i) Alternative F'_{31}

The first alternative considered uses an improved version of the standard Navy delivery system for handling the narrative message. First, the set of CMI narrative messages must be translated by the computer from the ASCII code to the Baudot code which is compatible with the AUTODIN system. Software will have to be developed or obtained off the shelf to make such a conversion at the CMI computer. Next, the standard message header, stored in the computer, and the date/time group would be added to the message by the computer. The total message would then be outputted from the CMI computer in the form of a paper tape which would then be manually delivered to the Memphis NAS TCC for transmission. The TCC operator would then insert the paper tape into the AUTODIN paper tape reader where it would be transmitted to the appropriate fleet center and then over the fleet broadcast via GapSat.

There are two types of message header formats used today, JANAP 128 (Joint Army Navy Air Force Publication 128) and Modified ACP 126 (Allied Communications Publication 126). The latter is used by the fleet for all ship-to-shore communications and, by exception, for certain shore-to-ship communications. CNTC recommends that we also use the Modified ACP 126 header for a limited number of the Memphis-to-ship messages for the following reason. As the ship moves from port to different locations and back to port, the Communications Station servicing it changes and hence so does its Routing Indicator. Under the current procedure using JANAP 128, the message to the ship would always automatically be rejected to an operator to insert the current Routing Indicator, thus losing time, because the current system has not fully automated this process as yet for moving ships. However, if Memphis uses the Modified ACP 126 header, the message will always be routed to the nearest NAVCOMPARS serving that ship's area, and since the NAVCOMPARS has a data base which always knows the ship's current address, it will affix it to the message automatically, thus routing it properly.

(ii) Alternative F'_{32}

This alternative is the same as F'_{31} but eliminates the manual transport function by connecting the CMI computer to a teletype at the TCC through a dedicated land line. Thus, the same complete message as constructed by the CMI computer, including message header and date/time group, would be punched out on paper tape at the TCC. When the operator sees the paper tape, he knows this is a message to be transmitted, so he logs in the message and feeds it into the AUTODIN tape reader.

(iii) Alternative F'_{33}

This alternative is identical to Alternative F'_{32} except it connects a TCC teletype to the land line only when needed. In this case, when the total reply message has been completely generated by the computer, it is stored in intermediate storage and the computer notifies the computer operator that the reply message is ready for transmission to the ship. The computer operator telephones the TCC operator saying he has a message to go out. The TCC operator then connects the land line to a spare teletype and notifies the computer center operator that the circuit is ready and that the message can now be transmitted from the computer's intermediate storage. After the paper tape is generated at the TCC, the remaining operations described previously continue.

(iv) Alternative F'_{34}

This alternative automates the procedure even more than F'_{33}. Now the land line from the CMI computer intermediate storage goes through a TCC patching panel to the appropriate connection inside the paper tape reader which supplies the signal for the AUTODIN line. Thus, when the CMI computer operator calls the TCC operator for message transfer, the operator completes the paper tape message which may be feeding the tape reader at that time, switches the computer line to the inside of the reader and notifies the computer operator to transmit the reply message from the computer, thus feeding it directly into AUTODIN.

An evaluation of these F'_3 design alternatives was made and F'_{31} selected as the preferred alternative. The rationale for this choice is given in the section on Evaluation of Alternatives.

(f) F'_1: Converting Navy Message to Printed Copy

After the ship receives the reply message transmission, it is stored in the NAVMACS system, for subsequent conversion to readable form. As shown in Figure III-8, two alternatives were examined for performing this function.

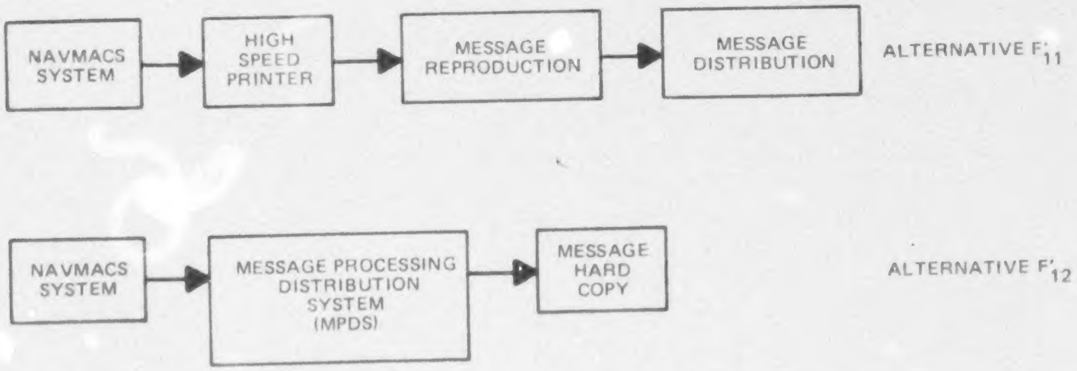

NAVMACS SYSTEM
HIGH SPEED PRINTER
MESSAGE REPRODUCTION
MESSAGE DISTRIBUTION
ALTERNATIVE F'_{11}
NAVMACS SYSTEM
MESSAGE PROCESSING DISTRIBUTION SYSTEM (MPDS)
MESSAGE HARD COPY
ALTERNATIVE F'_{12}

Figure III-8. CMI Message Printing and Distribution (F'_1 Alternatives)

(i) Alternative F'_{11}

This uses the standard Navy telecommunications procedure. Each of the CMI messages making up the total Navy message is converted into hard copy form over the high speed TT-624 printer at a speed of 800 lines/minute (each line consisting of 80 characters). The separate CMI reply messages for the student addressees are separated for distribution. Reproductions of the messages for the LS, or any other person, could also be made at the ship's TCC. Each message would be placed in the appropriate distribution box of the addressee's work station where it would be carried to the addressee's incoming mail point for his pick-up.

(ii) Alternative F'_{12}

An alternative method of distributing the message from the ship's message center to the addressee involves the use of the Message Processing Distribution System (MPDS) now installed on the U.S.S. Nimitz and to be installed on other ships in the future. This system uses a VDT display at a user location so that messages can be sent directly from the ship's message center, thus avoiding manually distributing the message. However, the MPDS is installed only on the Nimitz.

An evaluation of these F'_1 design alternatives was made and F'_{11} selected as the preferred alternative. The rationale for this choice is given in the section on Evaluation of Alternatives.

(2) Evaluation of Navy Message System Design Alternatives

Figures III-6 through III-8 illustrate the various design options considered for each of the functions of the Navy message communications system. As shown, there are five alternatives for F_1, one alternative for F_2, five alternatives for F_3, for transmitting a message from ship to shore, four alternatives for F'_3, one alternative for F'_2, two alternatives for F'_1 for transmitting a message from shore to ship. However, by recognizing that each function is independent of one another, we can choose the preferred alternative for each function separately, and thus arrive at the preferred solution in a simpler fashion.

The preferred alternative for each function was selected by reviewing the set of performance and cost criteria shown in the later section on evaluation of communications systems. However, the basic criteria used in designing the Naval Communications System for the demonstration were:

- Minimizing any changes in the current operational procedure used by Navy communications personnel.
- Minimizing the time spent by Navy communications personnel on the CMI messages.

The preferred system design alternative which is recommended for the demonstration is the standard Navy message system using the functions:

- F_{13}, OpScan 17 and teletype located in the message center.
- F_2, standard NAVMACS A-Plus system and AUTODIN
- F_{31}, carry paper tape from Memphis message center to CMI computer center, and read into computer intermediate storage.
- F'_{31}, carry paper tape from CMI computer, and read into AUTODIN reader.
- F'_2, AUTODIN and standard Navy message system.
- F'_{11}, standard Navy printing and distribution system.

The evaluation used to select each of these alternatives now follows.

(a) Evaluation of Function F_1: CMI Message Conversion and Transport to Ship's Message Center

The preferred alternative is F_{13}, locating the OpScan and the teletype in the message center. There were basically three key issues involved in evaluating the five design alternatives for F_1, as was illustrated in Figure III-4.

- Do we use the OpScan 17 plus teletype or just the teletype?
- Where should the OpScan 17 and the teletype be located?
- If the OpScan 17 malfunctions and cannot be repaired in time, what is our back-up approach for inputting the CMI message into the communications system?

These issues were addressed in the following manner, thereby arriving at the preferred design alternative for F_1.

(i) OpScan 17 Plus Teletype Versus Teletype Alone

For ease of operation we decided to use the OpScan 17 and a teletype as the primary means of generating a paper tape for the message input. However, we also know that there may be reliability problems with the OpScan. Thus, not only must it be located in a temperature/humidity controlled environment, but a system checkout test prior to transmission is also recommended. A complete system check of F_1 can be made by inserting a set of standard pattern test sheets and checking the results on the teletype monitor roll. Thus, a standard teletype (UGC-6) containing such a display should be used rather than just a paper tape punch. In addition, both pieces of equipment should be located alongside so that the system check can be readily conducted.

Since we may have equipment malfunction problems, it is essential that sufficient spare parts be available to balance the equipment failure rate with the response time of the ship's logistics system. If we can afford the cost and off-line space requirements, we would like to have a spare OpScan 17.

(ii) Equipment Location

The teletype will only be used a small amount of time per day. Hence, it is very inefficient to completely tie up a teletype for this small amount of usage. The ideal approach would be for us to use an existing spare teletype, already part of the ship's set of equipment (and hence a "free" resource). Probably the spare teletype would be located in the TCC. However, this would require that the OpScan 17 also be installed alongside for the system check. If such room is not available, there are two other possibilities. Both pieces could be located elsewhere if the spare teletype can be moved to the TCC when the spare is needed there. If this is not possible, a separate (non-spare) teletype and the OpScan 17 could be located in any other environmentally controlled area.

(iii) Back-up to OpScan 17

There will exist certain times when the desired response time for a CMI reply message will not be achieved, for several reasons:

- The OpScan 17 will not function properly and hence there will be a delay in transmitting the original message.
- The CMI computer (or any other part of the rest of the system) will malfunction and be unable to respond on time.

In these cases the following back-up procedures will be employed, as shown in Figure III-9.

- If the OpScan 17 fails and it appears that it will not be repaired in sufficient time to obtain the CMI reply in time, the LS may choose to type each of the test results on the UGC-6, in narrative form: (Student Identification; Question 1: B; Question 2: D; etc.). This will generate a paper tape for transmission. The message cover sheet would also indicate that the message is in narrative form so that the radioman would so indicate this on the header. Thus, when the narrative message arrives at Memphis NAS TCC, it would be printed only in narrative page form rather than also on a tape. When the narrative message is delivered to the CMI computer, it will be keypunched onto cards, fed into the computer, and processed like a normal CMI message, using their existing software. The message reply would be as previously described.

  The LS has another procedure available. He can score the test by hand, using an answer book available to him. He then determines any remedial loop necessary, based on the set of student

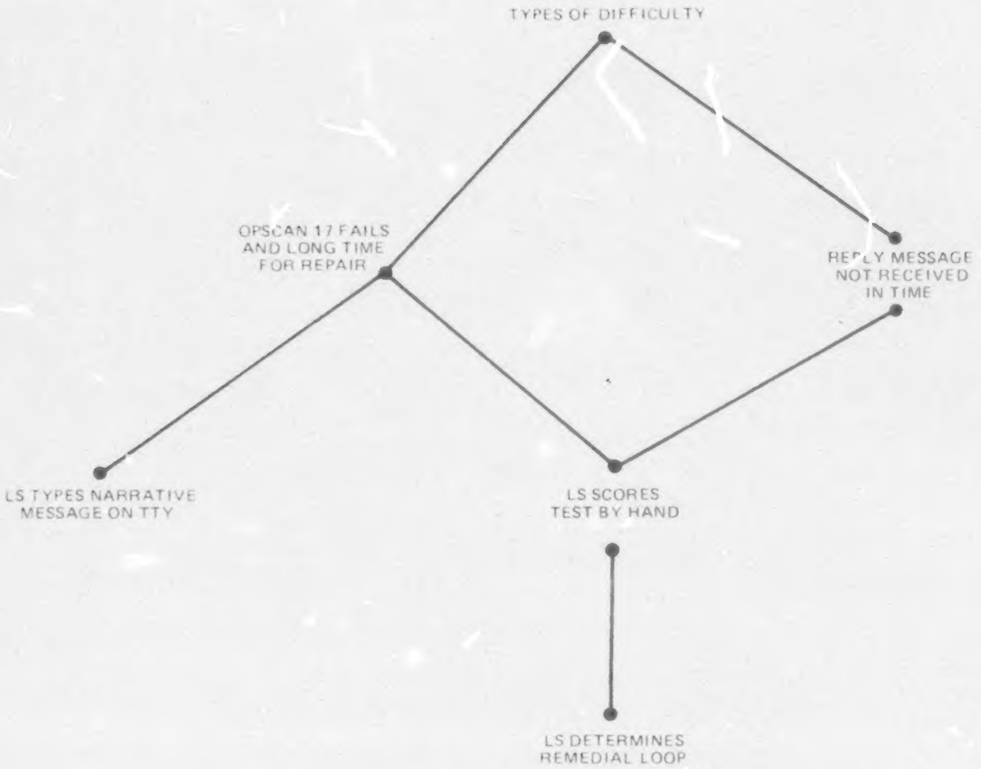

TYPES OF DIFFICULTY
OPSCAN 17 FAILS AND LONG TIME FOR REPAIR
REPLY MESSAGE NOT RECEIVED IN TIME
LS TYPES NARRATIVE MESSAGE ON TTY
LS SCORES TEST BY HAND
LS DETERMINES REMEDIAL LOOP

Figure III-9. Backup Procedures

test answers, by using a second answer book developed for such purpose. It should be emphasized that this procedure is recommended for the demonstration only, when only 30 students are involved. During the demonstration we shall gather performance characteristics regarding the magnitude of the system reliability problem, and based on this we shall determine how to cope with this problem for the operational system.

- In a similar fashion, if the reply message is not received by a certain time before the students' training period is to begin, the LS may also decide to score the test and determine the students' assignments, as described above.

The use of chemically treated test paper[1] may alleviate this problem by eliminating the job of scoring each test. The ideal system might be designed as follows:

- Design the chemically treated paper so that not only will the correct answer appear, but also it will be readable by the OpScan 17.
- Have all students take their test using this chemically treated paper.
- If the OpScan 17 is available for transmitting the test results to Memphis, use it. If not, the LS scores each test using the crayon and manually determining the remedial loops using the answer book. When the OpScan 17 does become available, the LS transmits the stack of tests so that the computer will maintain the complete record of student progress. However, he adds a pre-programmed symbol that no replies are needed since they have already been given to the students. This reduces unnecessary reply communications.

If the OpScan 17 malfunctions and the LS decides to teletype the test results in narrative form, the use of the chemically treated paper would:

- Reduce the typing manpower required by the LS.
- Reduce the typing error rate.
- Reduce message length, although this may not be very valuable since our total daily requirements are reasonably small now.

Since the chemical paper costs an extra amount (to be determined), this should be used only if absolutely required by excessive OpScan unavailability or other system malfunctions. We should also determine how rapidly these papers could be constructed and procured, if needed, since the 30-day pre-demonstration trial run on the ship may be our first indication of equipment breakdown.

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[1] This is specially treated test paper which will disclose the correct answer symbol when a special crayon is rubbed on the alternative answer locations.

(b) Evaluation of Function F_3: CMI Message Transfer from AUTODIN to CMI Computer

The preferred alternative is F_{31}, using the standard Navy delivery system. With this option, the messages are converted to paper tape, with the Memphis NAS TCC telephoning the CMI computer center to notify them of its arrival and the computer center picking it up and reading it into their intermediate storage device, through their own tape reader.

There are basically three key issues involved in the five design alternatives for F_3, as illustrated in Figure III-6.

- Should the AUTODIN message come into the Memphis NAS TCC or be routed into the CMI computer center directly from the AUTODIN switch in Albany, Georgia, or through the nearest LDMX to Memphis?
- Given that the message comes into the Memphis TCC, will it be hand-carried to the CMI computer center, or will it be transmitted over a land line?
- If the message is hand-carried from the message center, should it be on paper tape or on magnetic tape?

These issues were addressed in the following manner, thereby arriving at the preferred design alternative for F_3:

(i) Does the Message Go to TCC or Directly to the Computer Center?

While the possibility of automatically routing the message directly to the computer center is attractive, there are two major problems connected with this alternative. The primary problem is the security aspect. It would seem if the AUTODIN signal went directly to the computer center, security regulations would require that the computing center be treated as a secret facility, since there would always be some possibility that a classified message might inadvertently leave the AUTODIN line and be transmitted to the computer center termination. It is questionable if the computer center would go along with such a restriction. The second disadvantage is cost. While an automated delivery system is very attractive for the operational system with a high volume of messages coming in at different times, the small volume of messages for the demonstration system (one or two a day) does not seem to justify the associated costs. The main savings would be in time (perhaps 10 to 20 minutes for the one mile trip each way), and the associated manpower savings.

(ii) How to Transmit the Message from the TCC to the Computer Center

Here the same advantage of faster delivery time (perhaps 20 minutes) must be balanced against the costs of automatic delivery. These costs would include a leased line of one mile ($81 per month plus a one-time installation cost of $50 per device at each end,[1] an additional piece of equipment (paper tape or magnetic tape machine at one of the sites), as well as special handling effort on the part of the TCC (although this may only be a matter of several minutes a day to set up and remove the tape from the tape reader).

(iii) Hand-Carried Message on Paper Tape or Magnetic Tape?

Here we must compare the total costs of a new piece of equipment (magnetic tape machine) for the Memphis TCC and its operation and maintenance against similar costs of an additional piece of equipment (paper tape reader) at the computer center plus the cost of any interface efforts (and software changes) that the computer center may have to bear. It would seem that any additional effort required should be borne by the computer center rather than the TCC.

(3) Summary of Resources Required for Option 1

The purpose of this section is to summarize the operational steps required to operate the recommended system and list the various resources required. The resources required are listed in Table III-3. If any part of the recommended system cannot be implemented for any reason, one of the other design alternatives will be implemented.

---

[1] These figures do not assume the use of GSA Telpak rates, as do the long distance figures.

- Construct the Navy ship-to-shore message, once or twice a day. This requires:
  - -- OpScan 17. CNTECHTRA (Chief of Naval Technical Training) provides one prime unit of equipment which can interface with UCC-6 teletype, one spare unit, set of spare parts; Navy installs in ship's TCC and maintains.
  - -- Standard teletype (UGC-6). Use spare installed in TCC; Navy maintains.

Table III-3. Resources Required for Navy Message System

Equipment	Cost ($1000)	O&M Personnel	Man-Hr./Wk.
Ship			
1. SST	Navy provides service	Navy provides service	
a. Investment b. Installation c. Spares d. Tear Down and Restore			
2. OpScan 17 (2)			
a. Investment	2 @ 9.3 = 18.6	Learning Supervisor operates	Full time (7 mo.)
b. Spares	6.5	Navy ET maintains	2 hr./wk. (7 mo.) = 61 hours
c. Interface	2.0		
TOTAL 2	27.1		61 man hours + Learning Supervisor (7 mo.)
3. Memphis NAS TCC	Navy provides service	Navy provides service	
4. CMI Computer Center		Courier picks up tape and returns reply.	3 @ 20 min./day = 5 hr./wk. (7 mo.) = 152 man hours
a. Software Changes	NETISA estimated 70		
b. Tape Reader/Punch – Investment	Navy supplies	Operator operates	3 @ 20 min./day = 5 hr./wk. = 152 hours
TOTAL 4	70		304 man hours
GRAND TOTAL –			
Shipboard Site	97.1		365 man hours + Learning Supervisor (7 mo.)

Shipboard Cost: (1)+(2)+(3)+(4)

  - LS constructs paper tape of message text. Less than one half-hour of instructor time per message, plus time for him to walk to and from TCC.

- Navy transmits message.
  - Radioman logs in message, sets up and removes message from tape reader, after adding header and trailer. Ten minutes per message.
  - Satellite transmission. 5,454 to 6,522 characters per day.

- Transmission through rest of Navy/DCS system. No additional cost.

- Memphis NAS TCC handling. No additional effort required over their usual services.

- Computer center picks up message. Ten minutes per message of computer center personnel.

- Computer center inserts message into the computer.
  - Paper tape reader. NETISA procures; Memphis central electronic maintenance personnel maintain.
  - Modification to computer to accept message. Software modification; extent to be determined by NETISA.

- Computer translates message teletype format into CMI format.
  - Computer software modification or microprocessor for Baudot to ASCII conversion; extent to be determined by NETISA.

- Computer handles message. Non-differentiating cost for all design alternatives.

- Computer reply message configured and translated into standard Navy message format. This requires computer software modification; the extent of which is to be determined by NETISA.

- Computer center delivers message to message center. Ten minutes of computer center personnel per message.

- Message center handling. No additional effort required over their usual service.

- Transmission through rest of Navy/DCS system. No additional cost.

- Navy transmits message over full period termination channel. 107,330 characters per day.

- Reproduce and print message. No additional cost over usual service.

b. Option 2--Ship-to-Memphis Transmission via Navy Voice Circuit

(1) Description

A second communications system concept considered was to transmit the data signal from the ship to the CMI computer using a Navy voice circuit in the same way that the CONUS CMI now operates. This system would operate as follows. The set of test messages to be transmitted would be stacked on the OpScan 17. When a GapSat voice circuit would become available, the OpScan 17 would be patched into the circuit and operated, transmitting this signal to the fleet center with subsequent transmission of the message over telephone lines to the CMI computer at Memphis. The success of this concept depends on the availability of a GapSat voice circuit and hence, while the concept may be feasible from a technical viewpoint, it may not be practical. In any case, three different system designs were considered using this concept and these are described here for consideration.

(a) System 1--Complete Store and Forward System

Figure III-10 is a flow diagram showing the flow of digital data from the ship to the CMI computer. Again, there are the three major functions involved in transmitting CMI messages to shore over this path:

- F_1 is the function which stores and converts the CMI messages into electronic form for transmission to the CMI computer center.
- F_2 is the standard Navy voice circuit which transmits the message from the ship to the fleet center.
- F_3 is the voice circuit which goes from the fleet center to the CMI computer center.

Each of these functions will now be described.

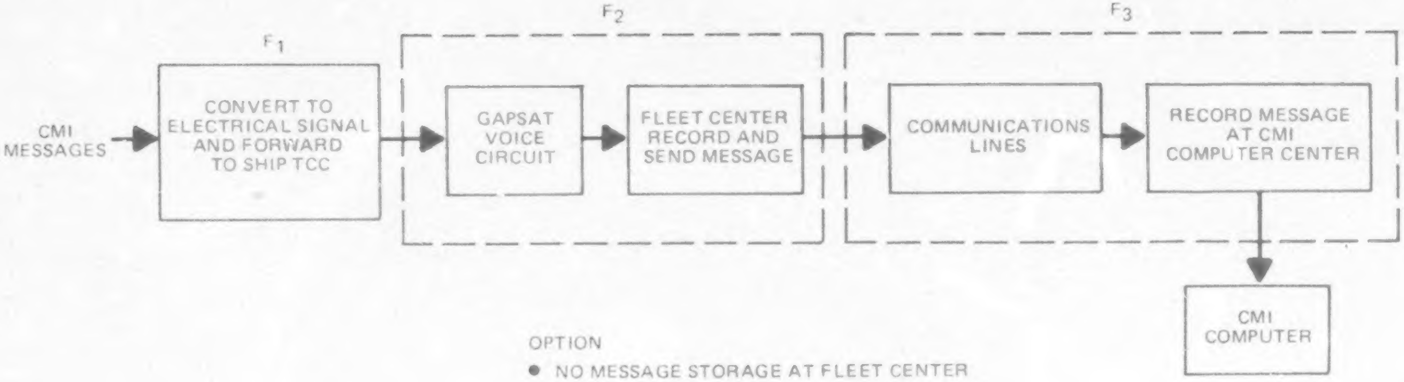
F1
F2
F3
CMI MESSAGES
CONVERT TO ELECTRICAL SIGNAL AND FORWARD TO SHIP TCC
GAPSAT VOICE CIRCUIT
FLEET CENTER RECORD AND SEND MESSAGE
COMMUNICATIONS LINES
RECORD MESSAGE AT CMI COMPUTER CENTER
CMI COMPUTER
OPTION
● NO MESSAGE STORAGE AT FLEET CENTER

Figure III-10. Ship-to-Shore Transmission Via GapSat Voice Channel

(i) F_1--CMI Message Input to GapSat

The objective of Function F_1 is to convert the information on the CMI messages into an electronic signal and send this as a modulating signal to the GapSat terminal. This system uses the same preliminary procedure described under the Navy Message System:

- The LS takes his CMI tests to the location where the OpScan 17 and teletype is located.
- Using the specially prepared test messages, the LS tests the availability of the OpScan 17, reading the results on the teletype.

The real set of CMI tests are then stored on the OpScan 17 and the LS requests a voice circuit for the short time required (less than 1/2 minute) from the TCC.

When the voice circuit is shortly to become available, the LS is notified and he connects the OpScan 17 to a telephone through either an acoustic coupler or a direct wire, as determined by the ship. When the radioman informs the LS that the voice circuit is now his, the LS speaks into the telephone giving the identification of this message, including ship, date, time, CMI message number to the CMI computer at Memphis, etc., and then starts the OpScan 17 readout. The LS listens to the tone signals to make certain the message is entering the voice circuit satisfactorily and completely. When the message has been completed, he states this over the circuit (as part of the message), which is also used as a signal to the radioman that it is complete, (or he hangs up, which also serves as this signal).

(ii) F_2--Transmit Message to Fleet Center

The message is thus transmitted over GapSat to the appropriate fleet center (Honolulu for the East Pacific, Guam for the West Pacific, Norfolk for the Atlantic, and Naples for the Indian Ocean) where it is recorded on magnetic tape, following a net control request for this service from the ship's technical control center to the CAMS technical control over the orderwire.

(iii) F_3--Transmit Message from Fleet Center to CMI Computer Center

The next step is to relay the recorded signal to the CMI computer center which can be done in the following ways:

Alternative F_{31}

A dedicated telephone line (costing $500 per month) connecting the Norfolk Fleet Center to the CMI DataNet at Memphis would allow forwarding of the recorded signal by a radioman in the fleet center (in the same way that the CW operator or Sub Broadcast Operator handles these types of Navy messages). The signal would be recorded on magnetic tape at Memphis in exactly the same way that Memphis handles courses with Pensacola, using the same equipment (dedicated line to magnetic tape recorder IBM 2968 into their DataNet), and then into the CMI computer. The only disadvantage of this approach is the manpower required for the fleet center to operate the magnetic tape equipment.

Alternative F_{32}

An alternative approach would be to use a standard commercial long distance call from the Norfolk Fleet Center to the magnetic tape recorder at Memphis. This would be less expensive than the dedicated line for the short time use involved.

Alternative F_{33}

Another alternative would be using conventional AUTOVON for the telephone line. This may involve adjusting the levels of the AUTOVON line, because varying traffic loads on the AUTOVON system are not always properly compensated; hence, levels are not uniform and adjustments may be needed. At each station through which the voice circuit passes, a certain noise floor and distortion level exist. The difference between these two is the dynamic range. The nominal voice level is set between these two extremes such that good voice quality is obtained at all times. Variable attenuators are used to make the adjustment at each location. The main cause of level variation is the traffic load on the system (usage of other channels). The operator at each station adjusts his incoming and outgoing level to nominal values, altered only by the need to compensate for channel loading condition. Too high a level at a given point will allow crosstalk to enter the channel.

We estimate that the total time required to make this level adjustment is from 20 to 40 minutes.

Alternative F_{34}

If the fleet center is at Honolulu, F_3 could either be the AUTOVON or the ARPA network (Aloha Net) from the University of Hawaii to CONUS. Currently, this network goes to Montgomery, Alabama. Thus, we would also need phone lines from the Honolulu Fleet Center to the Aloha Net, and from Montgomery to Memphis, using either of the options described previously.

(iv) Return Path--CMI Center to Ship

The return message path was also analyzed, and it was found that the identical approach could also be used for this return path. That is, as soon as each of the CMI message replies becomes available (approximately 6 seconds after receipt of each original message) it is immediately transmitted back to the fleet center over the return path where it is recorded on a separate track of the magnetic tape recorder. When the voice channel next becomes available, the recorded reply signal is transmitted from the fleet center to the ship, where it is patched into a terminet located at the learning center, and the CMI narrative reply messages are converted into page copy.

(b) System 2--Total Path Continuity System

A second system using a voice circuit avoids the store and forward concept described previously and simultaneously sets up the entire voice path (of F_1, F_2, and F_3), ~~and~~ then transmits the OpScan 17 signal directly to the Memphis computer. In this system, the LS again contacts the ship's TCC requesting a voice link to Memphis. About 30 minutes before this voice link will be available to the LS, the Ship's Technical Control contacts the Fleet Center Technical Control over the orderwire and requests a voice path to the Memphis CMI computer. Fleet Center Technical Control dials up such a path using any of the options delineated previously (AUTOVON, ARPANET, leased lines, etc.), and sees that the necessary line level adjustments are made for satisfactory transmission of the signal.

When this path is satisfactorily connected, Tech Control notifies the ship's TCC (over the orderwire) that the path is available, and when the satellite voice channel next becomes available the radioman notifies the LS to transmit the message, as previously described. Following transmission of this voice link, the rest of the operations occur, as previously described.

(c) System 2--Reply via Navy Message System

Both preceding voice circuit alternatives require a terminet on board the ship to receive the reply messages. One way of avoiding this is to use a hybrid system, one which uses the voice circuit from ship to shore but uses the Navy message system to produce the narrative reply messages. This approach would require that the CMI computer have the ASCII to Baudot translator, as described previously.

(2) Evaluation of Navy Voice Circuit Systems

In the case of the voice circuit approach for transmitting the CMI message, the alternatives differ in the way of implementing F_2, the Navy/AUTOVON (or other voice circuit mode), since F_1 and F_3 are the same for both systems. These two alternatives for F_2 are:

- F_{21}, store signal at fleet center and forward later.
- F_{22}, connect GapSat to rest of voice circuit path, adjust line and allow transmission to occur simultaneously, avoiding forwarding.

Of the two, the preferred system design alternative recommended for the demonstration is F_{21}, which offers the distinct operational advantage of being able to transmit the message at any time the GapSat voice circuit is available for approximately one minute. It avoids having to coordinate GapSat availability with the availability of the rest of the path.

However, F_{21} does require a magnetic tape recorder at the fleet center to record the signals[1]; and it does impose the store and forward work requirements on the fleet center personnel. This involves setting up the recorder, recording the signal, disconnecting the recording and maintaining the recorder. All other fleet center efforts (arranging for the rest of the path and adjusting the line levels, if necessary) have to be done for both systems.

The resources required for this system are listed in Table III-4.

3. National Aeronautics and Space Administration Satellite Options

NASA has three Applications Technology Satellites (ATS) in operation. Two of them, ATS-1 and ATS-3, provide communication channels in the 136-138 MHz band, while the third, ATS-6, can provide service in the 3700-4200 MHz downlink and the 5925-6425 MHz uplink band. All three satellites operate through NASA's earth station at Rosman, North Carolina.

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[1] It is assumed that the one multitrack tape recorder can be modified at minimal cost to play back the CMI messages on one track and record the replies on another simultaneously. If not, a second tape recorder will be required at the fleet center.

Table III-4. Resources Required for Navy Voice Circuit System

Equipment	Cost ($1000)	O&M Personnel	Man-Hr./Wk.
1. SST	Navy provides service	Navy provides service	–
a. Investment b. Installation c. Spares d. Tear Down and Restore			
2. OpScan 17 (2)			
a. Investment	2 @ 9.3 = 18.6	Learning Supervisor operates	Full time (7 mo.)
b. Spares	6.5	Navy ET maintains	2 hr./wk. (7 mo.) = 61 hours
TOTAL 2	25.1		61 man hours + Learning Supervisor (7 mo.)
3. Terminet 1200 (2)	4.2/ckt x 2 = 8.4	Navy ET maintains	1 hr./wk. (7 mo.) = 30 hours
a. Investment	2.0	Programmers+: Navy provides ($40K)	
b. Spares	10.4		
TOTAL 3			30 man hours
4. Ship TCC		RM request Fleet Center record message	3 @ 2 min./day = ½ hr./wk. (7 mo.) = 15 hours
TOTAL 3			15 man hours
5. NAVCAMS			
Magnetic Tape Recorder		F.C. RM prepares recorder	3 @ 10 min./day = 2½ hr./wk. (7 mo.)
a. Investment	To be provided by NETISA*	F.C. RM records message	3 @ 1 min./day = ¼ hr./wk. (7 mo.)
b. Spares		F.C. RM obtains AUTODIN	3 @ 10 min./day = 2½ hr./wk. (7 mo.)
TOTAL 5			160 man hours
6. CMI Computer Center			
Software Changes	40.0		
TOTAL 6	40.0		
GRAND TOTAL	77.5 + cost of modified magnetic tape recorder **		236 man hours + Learning Supervisor (7 mo.)

* Commercial Version Cost = $9K + 1.8K spares

**If the hybrid system is used, the cost of the terminet is eliminated, but the cost of software changes to the CMI computer may increase to $70K, increasing the total cost to $95.1K.

Total cost must also include cost of return path using Navy Message System. Shipboard cost = (2)+(3)+(4)+(5).

+ Administrative Terminal Function

Thus the satellite and the earth station are available as the F_2 portion of the communications system, as illustrated in Figure III-11.

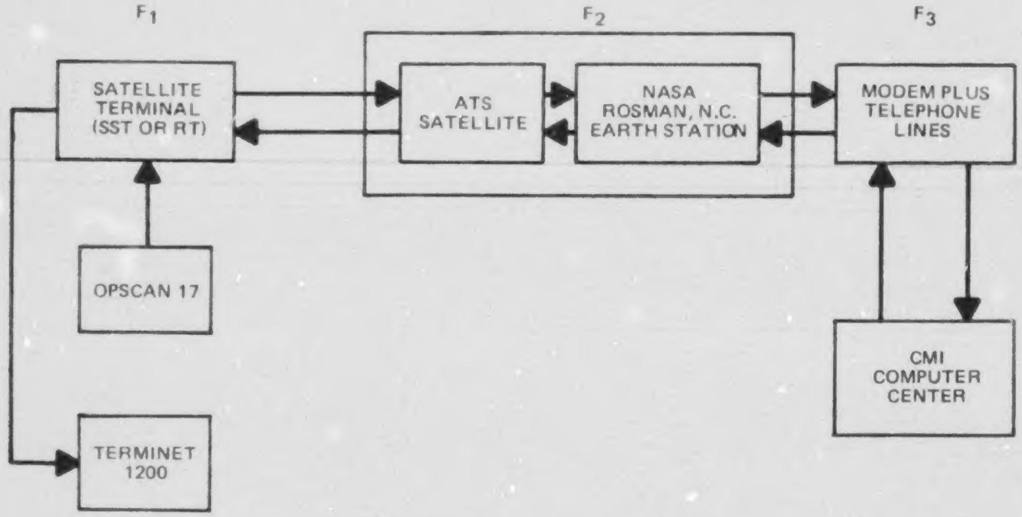
F1
F2
F3
SATELLITE TERMINAL (SST OR RT)
ATS SATELLITE
NASA ROSMAN, N.C. EARTH STATION
MODEM PLUS TELEPHONE LINES
OPSCAN 17
TERMINET 1200
CMI COMPUTER CENTER

Figure III-11. System Using NASA Satellites

These satellites all provide telephone channels, thus allowing the CMI system to be connected at each end as it presently is between Memphis and Orlando, Great Lakes and San Diego. Thus, no special classroom interface is required, and F_1 simply becomes the satellite terminal on board ship (SST) or at a remote land site (RT). The "shore interface," F_3, then consists of a modem, if required, and a telephone line connecting the Rosman, North Carolina, earth station, with the CMI computer center at Memphis.

Unlike the description of the Navy System where F_2 was fixed and F_1 and F_3 were designed to interface with it, in the case of the NASA systems the functions are more interrelated and it is easier to describe them together. However, for each of the systems, F_2 will be described first, since it determines the type of equipment required in F_1. Satellites ATS-1 and ATS-3 are treated together because they both operate in the 136-138 MHz band and thus both use the same type of terminal facilities.

a. ATS-1/3 Systems

(1) Description

Applications Technology Satellite 1 (ATS-1) is stationed at 150°W and has an 8° orbital inclination, which means that it traces a large figure 8 each day. It provides voice-band services in the 136-138 MHz VHF band. It has been operating for about eleven years, so its continued lifetime is a matter of conjecture.

Applications Technology Satellite 3 (ATS-3) is stationed at 70°W and has a 2° to 3° orbital inclination. It can no longer be maneuvered, but its communication circuits are still operational. It also provides voice band service in the 136-138 MHz VHF band. It has been operating for about nine years. Its continued lifetime is not known.

The choice between ATS-1 or ATS-3 for the demonstration is a matter of footprint coverage. A ship in the Atlantic or Eastern Pacific could be served by ATS-3, while a ship in the Pacific could be served by ATS-1.

The uplink and downlink frequencies are special assignments in the 136-138 MHz band. Only "experiment" type activities (and "demonstrations") can be conducted at these frequencies. Transmission time availability would be scheduled in advance by NASA. Coordination with NASA for circuit establishment would be required each day.

Terminals for either shipboard or remote land site use are available from NASA. Pitch-roll stabilization on board ship is not required because of the 40° antenna beamwidth. One of the terminals was used on the deck of the Kitty Hawk for an Apollo recovery mission near the equator. The antenna was directed straight upward at the satellite so there was no blockage from the ship's super-structure.

The antennas are 10' long each. Two are mounted at each end of a horizontal boom 10' long that is supported by a 10' vertical member. The antennas last only one month at sea, and cost about $120 each. For rotation, a diameter of about 20' is required to provide physical clearance. The antennas themselves are crossed-dipole Yagis. Only the Yagis are furnished by NASA. The mounting booms and rotator must be furnished by the user.

The terminal electronics consist of a 300 watt FM voice push-to-talk system. COMISAT data could be sent readily over such channels.

(2) Shipboard Operation

The antenna used for ATS-1 and ATS-3 is similar to the type of antenna used for home reception of fringe area television stations. In fact, it would be mounted on a similar type of rotator for ship's heading correction, and would be manually adjusted in azimuth and elevation. A major operational problem in the use of ATS-1 or ATS-3 would be onboard space to mount such an antenna. For rotation it requires a 20-foot diameter volume.

The modulation method to be used would be simple tone FM (i.e., FSK). There are no geographical restrictions on the use of this type of modulation such as exist with pseudo-random noise (PRN) coding, as will be discussed in connection with ATS-6.

(3) Remote Land Site Operation

ATS-1 and ATS-3 are currently providing two-way voice communications to and among remote land sites such as Alaska. They are well suited to this purpose. The earth terminal antenna configuration does not present a problem at such sites.

The interface at Memphis would be via a GDC-202-9D modem to a leased telephone line to Rosman, North Carolina, the same as is presently being used to San Diego, Great Lakes, and Orlando.

There would be no operational impact on the NETISA/Memphis CMI Center other than possibly the time of day when service is demanded, due to time zone differences between the classroom locations and Memphis.

(4) Evaluation of ATS-1/3

If ATS-1 and ATS-3 are still operational during the demonstration time period, they will be able to provide better time response than can be expected from the present Naval Telecommunications System. Turnaround is possible on a push-button basis and circuit availability is not subject to military traffic queues. This means fast (12 to 15 second) response to the student.

ATS-1 and ATS-3 have several clear disadvantages, however:

- Both satellites have been in operation well beyond their expected lifetime. If one should fail, the other could provide back-up service only where their coverage areas coincide (the eastern Pacific). No other satellites provide service of this type in this frequency band.
- Space on board ship for mounting the VHF antenna is a major question. Its size makes a mounting on the super-structure doubtful, and even lower mounting locations with enough space to allow for antenna rotation may be quite difficult to find.

(5) Cost Factors

Table III-5 shows the equipment and operation costs and manpower that would be required if ATS-1 or ATS-3 were to be used for the demonstration system. The equipment and operation costs are based upon NASA estimates and manufacturers' quotations and circuit tariffs, while the manpower costs are based upon joint discussions between PRC and U.S. Navy personnel.

Table III-5. Cost Factors for ATS-1/3

Equipment	Cost ($1000)	O&M Personnel	Man-Hr./Wk.
Ship			
1. SST		Navy ET learns system	Full Time (2 wks) = 136 hours
a. Investment	NASA provides	Navy ET operates	8-10 hr./wk. (7 mo.) = 243-303 hours
Spare Antennas	1.7	Navy ET maintains	4-5 hr./wk. (7 mo.) = 121-152 hours
Subtotal	1.7		
b. Installation	125-375		
c. Spares	18-36		
d. Tear Down and Restore (including SST restoration)	16-45		
TOTAL 1	160.7-457.7		500-591 man hours
2. OpScan 17 (2)			
a. Investment	9.3*/ckt x 2 = 18.6	Learning Supervisor operates	Full Time (7 mo.)
b. Spares	6.5	Navy ET maintains	2 hr./wk. (7 mo.) = 61 hours
TOTAL 2	25.1		61 man hours + Learning Supervisor (7 mo.)
3. Terminet 1200 (2)			
a. Investment	4.2/ckt x 2 = 8.4	Navy ET maintains Programmers+: Navy provides ($40K)	1 hr./wk. (7 mo.) = 30 hours
b. Spares	2.0		
TOTAL 3	10.4		30 man hours
Land			
4. RT		Navy ET learns system	Full time (2 wks.) = 120 hours
a. Investment	NASA provides	Navy ET operates	4-5 hr./wk. (7 mo.) = 121-152 hours
b. Installation	10-20	Navy ET maintains	3-4 hr./wk. (7 mo.) = 91-121 hours
c. Spares	15-26		
d. Removal and Restoration (including RT restoration)	6-12		
TOTAL 4	31-58		332-393 man hours
Rosman			
5. Memphis-Rosman Circuit	.1 + .3/mo.** x 7 mos. = 2.2	NASA operates earth terminal	1 @ 15-30 min./day = 1¼-2½ hr./wk. = 40-76 hours
TOTAL 5	2.2		40-76 man hours
6. CMI Computer Software Changes	40		
TOTAL 6	40		
GRAND TOTAL–			
Shipboard Site	238.4-535.4		631-758 man hours + Learning Supervisor (7 mo.)
Land Site	108.7-135.7		463-560 man hours + Learning Supervisor

*Includes "Device 273" and "LRC Character" for error detection and resend.
**Based on GSA-Telpak rate.
+Administrative Terminal Function
Shipboard Cost: (1)+(2)+(3)+(5)+(6)
Remote Land Cost: (2)+(3)+(4)+(5)+(6)

b. ATS-6 System

(1) Description

The ATS-6 satellite is located at 140°W and covers most of the Pacific Ocean as well as the Caribbean. The frequencies at which ATS-6 provides "earth coverage" transmission are heavily used by other satellites and the terrestrial systems as well. This means that the SST or RT must have a narrow beam antenna so it does not interfere with adjacent satellites or receive interference from them. On board ship, however, the narrow beam requires stabilization against ship's pitch and roll. A broad enough beam (e.g., 12° or more) would avoid the stabilization problem, but requires a special form of modulation called pseudo-random noise (PRN). PRN requires a special type of modem at the SST or RT, and a companion modem at the earth station (Rosman, North Carolina). Furthermore, the FCC may not allow the broadbeam shipboard antennas with their PRN coding to operate within 50 miles of certain ports where interference to terrestrial services is felt to be possible.

Thus the two alternatives for shipboard use are:

- Narrow beam (8' diameter) antenna stabilized with respect to ship's pitch and roll; clear mode transmission.
- Broad beam (10" to 18" diameter) antenna requiring no stabilization, but using PRN to prevent interference to and from other users of the same frequency bands.

The smaller-sized antenna is considered preferable because it is simpler to locate on the ship and to install and maintain. Its operation, however, may be restricted to ocean areas at least 50 miles from shore.

For the remote land sites there are no pitch-roll stabilization problems, nor are there the location and mounting problems found on board ship. For these reasons, remote sites using ATS-6 would have a narrow beam (8' diameter) antenna.

ATS-6 also has a 1.6 GHz capability, and 1.6 GHz terminals are available, but the 1.6 GHz antennas on ATS-6 are quite directional (a fan beam and a pencil beam). Their use would require special pointing of ATS-6 at the ship each time CMI transmissions are performed. NASA would thus require general knowledge of the ship's location. NASA is willing to do this special pointing, but, of course, added coordination is required each time the link is to be established each day.

A problem with either 1.6 GHz or 4-6 GHz use of ATS-6 is the lack of a suitable shipboard satellite terminal. Terminals for 1.6 GHz are available from the Maritime Administration but their size (four-foot dish on a five-foot diameter pedestal) presents problems with respect to shipboard mounting, especially in a location where the ship's structure and other antennas will not interfere with the line of sight from the antenna to the satellite.

ATS-6 can provide full duplex service throughout most of its coverage area, and half duplex service with quick turnaround out to the edges of its coverage area. This means fast (12 to 60 second) response to the student.

The satellite's transponders and earth coverage antennas, as well as the services of the NASA Rosman, North Carolina, earth station, can be made available to Project COMISAT by NASA. However, NASA does not have a shipboard satellite terminal (SST) available that is suitable for COMISAT use.

If the shipboard antenna has a four-foot diameter, the signal will be transmitted directly by Rosman at a 5950, 6150, or 6350 MHz frequency (to be assigned by NASA) to ATS-6 at 140°W, and from there at 3750, 3950, or 4150 MHz to the ship. The cost estimate of this modification is $45K (Magnavox). If the shipboard antenna has a 10" to 18" diameter, pseudo-random noise (PRN) coding must be used to prevent interference to and from other satellites in adjacent orbital slots (±5°

from ATS-6). The PRN coding of the uplink signal and decoding of the downlink signal would be accomplished at Rosman by a companion unit to the one on board ship. Frequency and transmission time availability would be scheduled in advance by NASA. Estimates of the cost of these modifications are $119K (Magnavox); $87K (Georgia Tech), and $75K (Space Communications, Inc.). Coordination with NASA for circuit establishment would be required each day, in accordance with discussions held on June 30, 1976, at NASA/GSFC.

(2) Shipboard Operation

The 10" to 18" antenna options with PRN coding require no antenna stabilization against ship pitch and roll, nor do they require an attitude change on the part of the ATS-6. The ship antenna need only be pointed at the satellite (remote manual), and automatic course correction used to maintain its direction. Depending on where the antenna is mounted relative to the ship's super-structure, however, operations may be restricted to certain ship headings because of signal blockage problems. For this reason, the use of two antennas (switchable) is assumed. The use of PRN coding may restrict the system to operation at or beyond 50 miles from shore. Technically, this is an unrealistic restriction, but it was invoked on a previous shipboard PRN system by the FCC.

The use of a four-foot antenna is claimed by Magnavox to be suitable for clear mode 4-6 GHz operations. (An eight-foot diameter may be required by the FCC to prevent interference to and from adjacent satellites.) Either a four-foot or eight-foot antenna at C-Band will require pitch-roll stabilization. A four-foot antenna at L-Band can probably operate under Project COMISAT conditions without pitch-roll stabilization, but stabilization is usually supplied to assure communication continuity even under extreme roll conditions when it may be needed for emergencies.

(3) Remote Land Site Operation

NASA has a variety of terminals available that are suitable for remote land site operation. Since ATS-6 will generally be pointed toward CONUS, operation could be at 4-6 GHz or 1.6 GHz with some 2.1 GHz service also possible. On land, the size of the antenna could readily be 8' to 10' or more, and no stabilization or daily pointing is needed. PRN coding would not be used for operation with a remote land site.

The interface at Memphis would be via a GDC-202-9D modem to a leased telephone line to Rosman, North Carolina. This line would be of the same type as is being used for circuits to San Diego, Great Lakes, and Orlando. There would be no operational impact at Memphis other than possibly the time zone differences between the classroom location and Memphis.

(4) Evaluation of ATS-6

The ATS-6 satellite can provide better service than can be expected from the Naval Communications System during the early years of an operational CMI system (early 1980's). Turnaround is rapid and circuit availability is not subject to military traffic queues. Hence the demonstration results would represent the type of service obtainable from an operating system of the early 1980's using a dedicated training satellite.[1]

The ATS-6 has several clear disadvantages:

- Space on board ship for mounting the above-deck portion of the SST is limited. (This may result in super-structure blockage of the beam for certain ship headings.)
- There may be a restriction against PRN coding (10" to 18" dish option only) when the ship is within 50 miles of shore.

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[1] However, additional time delays of varying amounts could be inserted into the ATS-6 system to determine the effects of such delays on training if the Naval Communications System were to be used in operations.

- Coverage is limited to the Pacific and the Caribbean.

(5) Cost Factors

Table III-6 shows the equipment and operation costs and manpower that would be required if ATS-6 were to be used for the demonstration system. The equipment and operation costs are based upon NASA estimates and manufacturers' quotations and circuit tariffs, while the manpower costs are based upon joint discussions between PRC and U.S. Navy personnel.

4. Domestic/Commercial Satellite Options

a. Description

A group of domestic/commercial satellites now serve the 50 states. One also serves Puerto Rico. These satellites, being commercial, are subject to tariff regulations which provide that they are to be used for point-to-point communication among land-based terminals. Users generally must pay for the lines from their locations to the nearest earth terminal.

These domestic satellite systems are available:

- Westar, owned by Western Union and capable of providing service throughout the 50 states. Three Westar transponders are leased on a protected basis to the American Satellite Corporation, which may launch its own satellites some time in the future.
- RCA Satcom, owned by RCA and capable of providing service throughout the 50 states. RCA Satcom serves many communities in Alaska, where RCA Alascom is the franchised common carrier.
- Comstar, owned by Comsat General and capable of providing service throughout the 50 states and Puerto Rico via earth stations owned by the American Telephone and Telegraph Company (AT&T) and General Telephone and Electronics (GT&E). Until April 1979, Comstar is not allowed to compete commercially with Westar and RCA Satcom, but serves AT&T and GT&E requirements, as well as certain military requirements.

Table III-6. Cost Factors for ATS-6

Equipment	Cost ($1000)	O&M Personnel	Man-Hr./Wk.
Ship			
1. SST (PRN, 14" dish)		Navy ET learns system	120 hours
a. Investment	75-149	Navy ET operates	8-10 hr./wk. (7 mo.) = 243-303 hours
Second Antenna	15- 30	Navy ET maintains	4-5 hr./wk. (7 mo.) = 121-152 hours
Subtotal	90-179		
b. Installation	125-375		
c. Spares	18- 36		
d. Tear Down and Restore	13- 38		
TOTAL 1	246-628		484-575 man hours
2. OpScan 17 (2)			
a. Investment	2 @ 9.3* = 18.6	Learning Supervisor operates	Full time (7 mo.)
b. Spares	6.5	Navy ET maintains	2 hr./wk. (7 mo.) = 61 hours
TOTAL 2	25.1		61 man hours + Learning Supervisor (7 mo.)
3. Terminet 1200 (2)			
a. Investment	2 @ 4.2 = 8.4	Navy ET maintains Programmers+: Navy provides ($40K)	1 hr./wk. (7 mo.) = 30 hours
b. Spares	2.0		
TOTAL 3	10.4		30 man hours
Land			
4. RT (clear, 8' dish)		Navy ET learns system	Full time (2 wks.) = 120 hours
a. Investment	75-129	Navy ET operates	4-5 hr./wk. (7 mo.) = 121-152 hours
b. Installation	40- 80	Navy ET maintains	3-4 hr./wk. (7 mo.) = 91-121 hours
c. Spares	15- 26		
TOTAL 4	130-235		332-393 man hours
Rosman			
5. Memphis-Rosman Circuit	.1 + .3/mo.** x 7 mos. = 2.2	Land terminal operated by NASA	1 @ 15-30 min./day = 1¼-2½ hr./wk. = 40-76 hours
TOTAL 5	2.2		40-76 man hours
6. CMI Computer Software Changes	40		
TOTAL 6	40		
GRAND TOTAL–			
Shipboard Site	323.7-705.7		615-742 man hours Learning Supervisor (7 mo.)
Land Site	207.7-312.7		463-560 man hours + Learning Supervisor (7 mo.)

*Includes "Device 273" and "LRC Character" for error detection and resend.

+Administrative Terminal Function.

**Based on GSA Telpak rates.

Shipboard Cost: (1)+(2)+(3)+(5)+(6)

Remote Land Cost: (2)+(3)+(4)+(5)+(6)

"Footprint" coverage areas for the domestic commercial satellites are shown in Appendix III-A. The earth stations for these satellites have an antenna diameter of at least 26 feet per FCC regulations to minimize interference to and from other users of the 3700-4200 MHz and 5925 to 6425 MHz bands.

The F_2 alternatives are the four domestic satellite carriers, Western Union, American Satellite, RCA, and Comsat General. The choice among them is a function of the distance from a given remote classroom to the nearest commercial earth station or access point, plus the same considerations at the Memphis end.

With respect to Memphis, the closest access city is St. Louis on the Westar system. Western Union pays the telephone costs from St. Louis to Chicago, where it has an earth terminal. This tends to make Westar somewhat more attractive than the other systems, but all have earth stations at Atlanta, Georgia, a distance of 330 miles ($200/month) from Memphis, compared with 250 miles ($150/month) for St. Louis.

A system other than Westar might be more attractive for a remote classroom located near an earth terminal of one of the other systems, for example. Appendix III-A contains a list of earth station cities and access cities for the various domestic commercial satellite systems. Certain of the "dedicated military" terminals might be used for a CMI demonstration if suitable arrangements can be made with the using agencies.

Domestic commercial satellites would provide full duplex service from the Memphis CMI center to the remote classroom in a manner identical with operation at Great Lakes, Orlando, and San Diego. The F_1 function thus is simply a telephone line connection from an earth station to the OpScan 17 and the Terminet 1200 in the remote classroom.

The F_3 function is identical to the present arrangement at Memphis, in which the CMI Computer Center is connected via telephone line to the distant classrooms.

b. Evaluation of Domestic/Commercial Satellite Systems

The full duplex service that would be provided by a domestic commercial satellite is better than the AUTODIN I service now available to land sites because the military traffic queues and half duplex limitations of the AUTODIN I system would not be present. The service would approximate that which an operational system of the early 1980's might experience with AUTODIN II. However, the interconnection needed with one of the 26' commercial earth stations is just as difficult as running a new telephone or AUTODIN line to a remote site.

c. Cost Factors

Table III-7 shows the equipment and operation costs and manpower that would be required if a domestic/commercial satellite were to be used for the demonstration system. Because all of the satellite carriers are subject to FCC tariffs, the rates for all of them are the same. The cost differences among them result only from the telephone line cost differences between the classroom and the earth station (remote) and between Memphis and the earth station or access city serving it.

The equipment and operation costs are based upon manufacturers' quotations and circuit tariffs, while the manpower costs are based upon joint discussions between PRC and U.S. Navy personnel.

5. ARPANET System

a. Description

The ARPANET is a communications system established among various universities and Defense Department locations to do unclassified research involving the interconnection of remotely located computers. Most of the traffic on the ARPANET is digital data but voice also has been sent on it. For transmission purposes, a data stream is broken into

Table III-7. Cost Factors for Domestic/Commercial Satellites

Equipment	Cost ($1000)	O&M Personnel	Man-Hr./Wk.
Land			
1. RT		Navy ET learns system	120 hours
a. Investment	75-125	Navy ET operates	8-10 hr./wk. (7 mo.) = 243-303 hours
b. Installation	50-100	Navy ET maintains	4-5 hr./wk. (7 mo.) = 121-152 hours
c. Spares	15- 25		
TOTAL 1	140-250		484-575 man hours
2. OpScan 17 (2)			
a. Investment	9.3*/unit x 2 = 18.6	Learning Supervisor operates	Full time (7 mo.)
b. Spares	6.5	Navy ET maintains	2 hr./wk. (7 mo.) = 61 hours
TOTAL 2	25.1		61 man hours + Learning Supervisor (7 mo.)
3. Terminet 1200 (2)			
a. Investment	4.2/unit x 2 = 8.4	Navy ET maintains Programmers+: Navy provides ($40K)	1 hr./wk. (7 mo.) = 30 hours
b. Spares	2.0		
TOTAL 3	10.4		30 man hours
4. Satellite Usage	7.7$^{\phi}$		
Memphis-Earth Station and Classroom-Earth Station Circuits	To be determined based on selected classroom location. Currently estimated at about 1.3		
TOTAL 4	9.0		
5. CMI Computer Software Changes	40		
TOTAL 5	40		
GRAND TOTAL–LAND	224.5-334.5		575-666 man hours + Learning Supervisor (7 mo.)

ϕ $1100/mo. x 7 months = $7700
* Includes "Device 273" and "LRC Character" for error detection and resend.
+ Administrative Terminal Function.
Cost = (1) + (2) + (3) + (4) + (5)

"packets," each typically 1,024 bits long. Each packet is then routed within the network along the best path available at the time the packet is to be sent. The packets are then re-assembled at their destination. The ARPANET has shown that packet switching can reduce the time required for a message to be sent from one network to another at a given volume of traffic density.

The ARPANET is a means whereby a remote land site classroom might be connected with Memphis, and hence is an alternative to the DCS/AUTODIN system, but does not require the Baudot code.

The F_2 function within the ARPANET is handled by a variety of means, including microwave, wire pairs, and satellite. As far as the CMI demonstration system is concerned, the F_2 function for the ARPANET can be regarded as comparable to that of a telephone circuit. From the COMISAT demonstration viewpoint, the two most important system nodes are at Honolulu and at Montgomery, Alabama, the closest node to Memphis.

The F_1 function for the ARPANET involves the obtaining of a telephone connection between the remote classroom with its OpScan 17 and Terminet 1200 and the nearest node on the ARPANET. The length of the required connection will be instrumental in determining any cost advantage in using the Net. Assuming that the ARPANET would only be used if the remote classroom were conveniently located (not more than 250 miles away) relative to an ARPANET terminal, the cost of the F_1 function is \$100 + \$0.60/mi./mo. x 250 miles x 7 months = \$1150, based upon GSA-Telpak rates.

The F_3 function for the ARPANET consists of a telephone connection between Memphis and Montgomery, Alabama. The cost for this link is estimated to be \$100 + (\$0.60/mi./mo. x 300 miles x 7 months) = \$1360.

b. Evaluation of the ARPANET

With respect to the CMI demonstration system, use of the ARPANET is quite comparable to the use of the present telephone network from Memphis to Great Lakes, Orlando and San Diego. Its packet switching should have minimal effect on the CMI data being transmitted. There may be some cost advantages in using the ARPANET, depending upon the location of the remote classroom, since the Net has a satellite link to Hawaii, as well as circuits to several European locations. Being a government system, it is not likely that usage charges would be incurred by the CMI demonstration system, as would be the case if regular commercial telephone circuits were to be used.

c. Cost Factors

Table III-8 shows the equipment and operation costs and manpower that would be required if the ARPANET were to be used for the demonstration system. The equipment and operation costs are based upon manufacturers' quotations and circuit tariffs, while the manpower costs are based upon joint discussions between PRC and U.S. Navy personnel.

6. Marisat Satellite Option

a. Description

The Marisat system uses the same satellites as does the Navy Gapfiller, but Marisat operates at commercial frequencies whereas Gapfiller operates in the military UHF band.

The Marisat satellites are owned by Comsat-General and provide commercial teletype and voice service in the Atlantic and the Pacific. Being commercial, they are subject to tariff regulations which provide that they are to be used only for communication with ships and with off-shore platforms. The Marisats use the following frequency bands:

Ship to Satellite	1638.5 - 1642.5 MHz
Satellite to Shore	4195 - 4199 MHz
Shore to Satellite	6420 - 6424 MHz
Satellite to Ship	1537 - 1541 MHz

Table III-8. Cost Factors for ARPANET

Equipment	Cost ($1000)	O&M Personnel	Man-Hr./Wk.
1. RT	Navy provides service	Navy provides service	
2. OpScan 17 (2)			
a. Investment	2 @ 9.3[*] = 18.6	Learning Supervisor operates	Full time (7 mo.)
b. Spares	6.5	Navy ET maintains	2 hr./wk. (7 mo.) 61 hours
TOTAL 2	25.1		61 man hours + Learning Supervisor (7 mo.)
3. Terminet 1200 (2)			
a. Investment	4.2/unit x 2 8.4	Navy ET maintains Programmers[+]: Navy provides ($40K)	1 hr./wk. (7 mo.) 30 hours
b. Spares	2.0		
TOTAL 3	10.4		30 man hours
4. Land Line Cost	2.5[ϕ]		
TOTAL 4	2.5		
5. CMI Computer Software Changes	40		
TOTAL 5	40		
GRAND TOTAL Land Site	78.0		91 man hours + Learning Supervisor (7 mo.)

[ϕ] $1,150 for classroom to ARPANET terminal and $1,350 for Montgomery, Alabama to Memphis, Tennessee.
[*] Includes "Device 273" and "LRC Character" for error detection and resend.
[+] Administrative Terminal Function
Cost = (1)+(2)+(3)+(4)+(5)

The SST's use four-foot antennas. Complete SST's can be purchased for $50,000, or can be leased for a two- to five-year period, over which the $50,000 is amortized. Comsat-General will entertain a request for proposal from Project COMISAT for a shorter lease period with incomplete amortization. (However, they have not yet stated that they would allow incomplete amortization.)

Marisat service is complete from the SST to the user's location in CONUS, i.e., Comsat-General pays for the terrestrial circuit between the user's location (CMI computer room at Memphis) and its earth stations at Southbury, Connecticut (for the Atlantic), and Santa Paula, California (for the Pacific).

b. Evaluation of Marisat

Marisat would provide full duplex service from the Memphis CMI center to the shipboard classroom, and would provide shipyard supervision of terminal installation by the Navy. The question of locations of the SST antenna on board ship remains, however. Two might be required on opposite sides of the super-structure for full service.

Operation via Marisat would be identical with operation at Great Lakes, Orlando, or San Diego, except for the shipboard environmental limitations on student terminal performance. The solution of any EMC problems would be the responsibility of Comsat-General.

As in the case of all of the "on-line" satellite alternatives, Marisat can provide better service than can be expected from the Naval Communications System during the early years of an operational CMI system (early 1980's). Turnaround is limited only by computer response time (12 seconds), and circuit availability is not subject to military traffic queues. Marisat more accurately simulates the expected time-shared military satellite service expected in the 1990's, or that which could be provided by a dedicated training satellite.

Marisat also has the same disadvantages as the other on-line alternatives. Space on board ship for mounting the above-deck portion of the SST as well as space below-deck may be difficult to find. (A poor location may result in super-structure blockage of the beam for certain ship headings.)

c. Cost Factors

Table III-9 shows the equipment and operation costs and manpower that would be required if Marisat were to be used for the

Table III-9. Cost Factors for MARISAT

Equipment	Cost ($1000)	O&M Personnel	Man-Hr./Wk.
1. SST		Navy ET learns system	120 hours
a. Investment	50	Navy ET operates	8-10 hr./wk. (7 mo.) 243-303 hours
b. Installation	125-375	Navy ET maintains	4-5 hr./wk. (7 mo.) = 121-152 hours
c. Spares	10		
d. Tear Down and Restore	13-38		
TOTAL 1	198-473		484-575 man hours
2. OpScan 17 (2)			
a. Investment	9.3*/unit × 2 = 18.6	Learning Supervisor operates	Full time (7 mo.)
b. Spares	6.5	Navy ET maintains	2 hr./wk. (7 mo.) = 61 hours +
TOTAL 2	25.1		Learning Supervisor (7 mo.)
3. Terminet 1200 (2)			
a. Investment	4.2*/unit × 2 = 8.4	Navy ET maintains Programmers+ Navy provides ($40K)	1 hr./wk. (7 mo.) = 30 hours
b. Spares	2.0		
TOTAL 3	10.0		30 man hours
4. Satellite Usage	22.8φ		
TOTAL 4	22.8φ		
5. CMI Computer Software Changes	40		
TOTAL 5	40		575-666 man hours + Learning Supervisor (7 mo.)
GRAND TOTAL	295.9-570.9		

*Includes "Device 273" and "LRC Character" for error detection and resend.

+ Administrative Terminal Function.

φ Based on 15 min./day, five days/week for 7 months.

Cost = (1)+(2)+(3)+(4)+(5)

demonstration system. The equipment and operation costs are based upon manufacturers' quotations, while the manpower costs are based upon joint discussions between PRC and U.S. Navy personnel.

7. High Frequency (HF) AUTODIN Option

a. Description

HF constitutes the 2.0 to 30 MHz portion of the radio spectrum that has been used for many years for international point-to-point as well as broadcast service. It is also known as "short-wave." The Navy has made extensive use of HF for ship-shore communication, and still does so. In the satellite era, HF continues to provide back-up and overflow service. With respect to the CMI demonstration, the communication path would consist of the same links as the Navy message system, except HF would be used from the ship to NAVCAMS instead of GapSat.

The chief disadvantages of HF, aside from severe spectrum crowding, are its unpredictable fades and outages, which result in intolerable error rates at times, combined with its daily, yearly and 11-year performance cycles. HF, however, continues to be used because of its ability to provide direct point-to-point circuits with relatively low power and because of substantial equipment investments on the parts of its many users.

Operation via HF would be identical to operation via Gapfiller except for longer queues and higher error rates. An error rate monitor must be included in any HF circuit used for CMI to clearly indicate times when propagation factors may alter some or all of the answers a student is sending. While it is true that propagation factors may cause long and obvious outages, they can also cause very brief error bursts in what appears to be a perfect transmission otherwise.

As with Gapfiller, HF circuits can be used for either shipboard or remote land sites. HF might be used for providing CMI at such remote locations as Diego Garcia, in the Indian Ocean, for example.

(In general, the F_2 function to most locations will be routed via Defense Communication System (DCS) links.)

Because HF is used with the standard Navy message system, the reader is referred to the discussions of the F_1 functional alternatives which appeared beginning on page 42, since these same considerations apply.

To reduce the probability of an erroneous message and the need for sending service messages with their attendant time response requirements, some form of error correction must be used. We recommend that the ASCII coded student message and other CMI traffic from the ship be transmitted three times, with each repetition spaced at least ten minutes (and preferably 30 minutes) from the previous transmission. Since HF errors occur in bursts, this will reduce the likelihood that the repeats may be caught in the same signal fade as the first transmission. The CMI computer would then store the first message and compare it with the second when it arrives. If there is perfect correlation, one of the messages is then processed by the computer and the reply transmitted. If any differences in any of the separate CMI message texts are found, that particular student's message is delayed until the third transmission arrives. An additional comparison of the errors in this message is made, using a "two out of three" rule for determining which symbols are correct. If such determination still cannot be made, a service message is sent, repeating the process. Since the reply message is in narrative form, only one transmission need be sent, although all numeric data will also be transmitted three times within each Navy message so that visual correlation can be made.

The NAVMACS A-Plus system, involving store and forward in the AN/UYK-20 computer, may or may not be available on a given ship or at a given remote classroom site. In fact, four situations are possible, as illustrated in Figure III-12, where the box labeled "MANUAL" implies

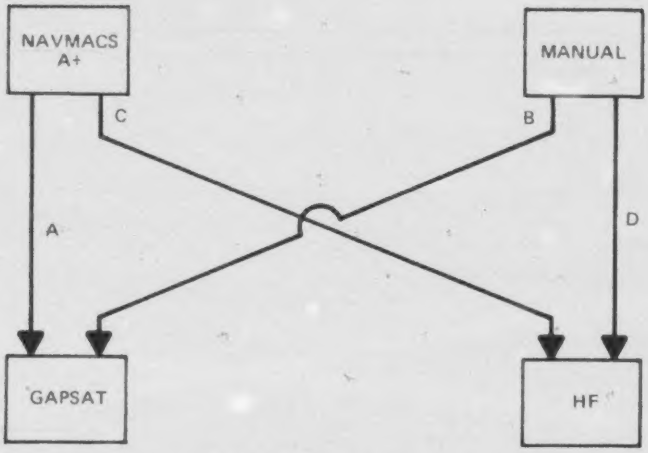

Figure III-12. Data Handling/Transmission Combinations

manual insertion of the CMI paper tape (generated by the student) into a tape reader.

Alternative A was described in connection with the discussion of "Transmission Via Navy Message Telecommunications System." Alternative B is an "on line" tape feeding operation, since the AN/UYK-20 store and forward function is not involved. Alternatives C and D are of primary interest in connection with the use of HF transmission. Alternative C allows the message system to continue accepting inputs even when transmission delays are occurring due to propagation outages. Thus, batching is automatically provided in the AN/UYK-20 computer. This is not possible with Alternative D, in which the learning supervisor or radio operator must simply wait until HF propagation conditions allow its transmission, or a new frequency can be found. If HF must be used, Alternative C offers much less chance for human error.

The reader is referred to the discussion of the F_3 function alternatives which appeared beginning on page 47, since these same considerations apply. If the F_2 function is handled via HF, however, the following additional comments apply.

For computer-to-classroom messages, much of the text is in plain English, so multiple transmissions will not be used. For numerics, two approaches will be tried:

- Check-sum digit, in which all the numerics in a given line are added and the last digit of the sum is sent at the end of the line.
- Formatted response, in which all the numerics in a message are repeated at the end of the message.

Any errors detected at the classroom end which cannot be corrected by the context or the correlation means described will result in requests for retransmission.

If the use of HF should become necessary, the results obtained from the two approaches to error detection/correction will be compared, and the best one will be selected for operational system use.

The use of HF would result in considerable operational impact on the Memphis CMI center. Not only would the center have to interface with AUTODIN I, but an error rate monitoring system would have to be used to detect the exact time of occurrence of circuit anomalies so that student results are not recorded or remedial work prescribed inaccurately.

b. Evaluation of HF/AUTODIN

HF presents problems of its own that should not intervene in a research program such as the CMI demonstration. While its use (with AUTODIN) possesses the realistic operational limitations of Gapfiller, it adds an error rate problem that will not exist on future military satellite service, even in the early 1980's. HF is not recommended for the CMI demonstration because a far better and more realistic medium, Gapfiller, is available. HF would place unrealistic and needless constraints on the demonstration and require additional resources to be expended for the error detection/correction function as described previously.

c. Cost Factors

Table III-10 shows the equipment and operation costs and manpower that would be required if the HF/AUTODIN alternative were to be used for the demonstration system. The equipment and operation costs are based upon U.S. Navy estimates and manufacturers' quotations, while the manpower costs are based upon joint discussions between PRC and U.S. Navy personnel.

D. Cost-Performance Analysis--Demonstration Communications Alternatives

1. Introduction

This section describes the Cost-Performance Analysis which was made in evaluating the various communications system alternative designs for the demonstration. As a result of this analysis, the Navy message communications system was selected for the demonstration because:

- It meets all requirements of the demonstration.
- It requires the least resources in personnel.
- It will permit the use of a ship's existing message system and communications equipment, thus eliminating the requirements for the installation of antennas or other communications equipment except for a small optical scanning device below deck to read the CMI tests.
- The demonstration will place a negligible load on the ship's communications system.

The content of this section includes:

- A comparison of the key performance characteristics obtainable from each of the alternatives considered.
- An analysis of all costs which would have to be expended in using each system during the demonstration.

2. Performance Analysis

Table III-11 is a summary of the results of the analysis of the performance expected from each of the demonstration system alternatives. Column 1 contains the 11 criteria used for the performance evaluation.

Table III-10. Cost Factors for HF/AUTODIN

Equipment	Cost ($1000)	O&M Personnel	Man-Hr./Wk.
Ship			
1. SST	Navy provides service	Navy provides service	
a. Investment b. Installation c. Spares d. Tear Down and Restore			
2. OpScan 17 (2)			
a. Investment	2 @ 9.3 = 18.6	Learning Supervisor operates	Full time (7 mo.)
b. Spares	6.5	Navy ET maintains	2 hr./wk. (7 mo.) = 61 hours
c. Universal Interface	2.0		
TOTAL 2	27.1		61 man hours + Learning Supervisor (7 mo.)
Land			
3. RT	Navy provides service	Navy provides service	
a. Investment b. Installation c. Spares d. Removal and Restoration			
4 Memphis NAS TCC	Navy provides service	Navy provides service	
5 CMI Computer Center		Courier picks up tape and returns reply	3 @ 20 min./day = 5 hr./wk. (7 mo.) = 152 hours
a. Software changes	70.0 (software)		
b. Tape Reader/Punch		Operator operates	3 @ 20 min./day = 5 hr./wk. = 152 hours
Investment	Navy supplies		
TOTAL 5	70.0		304 man hours
GRAND TOTAL –			
Shipboard Site	97.1		365 man hours + Learning Supervisor (7 mos.)
Land Site	97.1		365 man hours + Learning Supervisor (7 mos.)

Shipboard Cost: (2)+(5)
Remote Land Cost: (2)+(3)+(5)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Evaluation Criteria	**Navy Message System**	**Autodin (Land)**	**Navy Voice Channel System**	**ATS-1/3**	**ATS-6**	**Domestic/Commercial (Land)**	**ARPANET (Land)**	**MARISAT (Ships)**	**HF/AUTODIN**
1. **Installation Requirements**									
a. **Space Requirements**	Exists	Minimal	Exists	2 antennas + below deck space	2 antennas + below deck space	1 antenna	Minimal	2 antennas + below deck space	Exists
SST/RT Antenna Size	Part of WSC-3		Part of WSC-3	20' diameter required	10" to 18" (PRN) 4' (clear mode)	30'	No antenna	4'	- -
SST/RT Pedestal Size	Part of WSC-3	No pedestal	Part of WSC-3	2'	2' to 5'	- -	No pedestal	5'	No pedestal
SST/RT Below-Deck Cabinet Size	Part of WSC-3	Comparable to WSC-3	Part of WSC-3	22" x 24" x 72"	22" x 24" x 48"	- -	- -	22" x 24" x 48"	A variety of systems are available Most are comparable in size to the WSC-3
b. Installation Time	0	0	0	8 mos. development 4 mos. installation	8 mos. development 4 mos. installation	No development 4 mos. installation	0	No development 4 mos. installation	0
2. Frequency Band	240-310 MHz	- -	240-310 MHz	136-138MHz	3700-4200 MHz downlink 5925-6425 MHz uplink	3700-4200 MHz downlink 5925-6425 MHz uplink	- -	1537-1541 MHz downlink to ship 1638.2-1642.5 MHz uplink to ship	2-30 MHz
3. Operational Availability									
a. Geographical Constraints	Worldwide	Worldwide	Worldwide	ATS-1/3 Footprint	ATS-6 Footprint. PRN operation within 50 miles of shore requires FCC agreement	All 50 states*	48 states + Hawaii	Worldwide	Worldwide
b. Time of Availability	Memphis Schedule	Memphis Schedule	Memphis Schedule	1-2 hours/day	1-2 hours/day	Memphis Schedule	Memphis Schedule	Memphis Schedule	Memphis Schedule
4. Maintainability	Excellent	Excellent	Excellent	Good	Good	Excellent	Excellent	Excellent	Excellent
5. Transmission System									
a. Type	Half duplex	Half duplex	Half duplex	Half duplex	Full duplex at reduced power Half duplex at full power	Full duplex	Half duplex	Full duplex	Half duplex
b. Usage	5-6 Standard Messages-Send 89 Standard Messages-Reply	Same as Navy Message System	Same as Navy Message System	Same as Navy Message System	Same as Navy Message System	Same as Navy Message System	Same as Navy Message System	Same as Navy Message System	Higher usage than Navy Message System (x3) because of higher error rate
6. Message Response Time	Less than 8 hours	Less than 8 hours	Less than 1 hour	12 seconds	12 seconds	12 seconds	12 seconds	12 seconds	Highly variable
7. Additional Response Time for Transmission Errors	Less than 8 hours	Less than 8 hours	Less than 1 hour	12 seconds	12 seconds	12 seconds	12 seconds	12 seconds	Highly variable
8. Earth Station Characteristics									
a. Location	Norfolk, VA (Atlantic) Honolulu, HI (East Pacific) Guam (West Pacific) Naples (Indian Ocean)	- -	Norfolk, VA (Atlantic) Honolulu, HI (Pacific) Guam (West Pacific)	Rosman, N.C.	Rosman, N.C.	Various; within the 50 states	- -	Southbury, CN (Atlantic) Santa Paula, CA (Pacific)	Various Navy sites on the east and west coasts, Honolulu, Guam
b. Circuit to Memphis	Furnished by Navy and DCS	Furnished by Navy and DCS	Furnished by Navy and DCS	Leased line to Memphis, TN	Leased line to Memphis, TN PRN, if used, requires unit at Rosman	Furnished by carrier or user	Leased line from Montgomery, AL to Memphis, TN	Furnished by Comsat-General	Furnished by Navy and DCS
9. Interruption of Normal Work	Computer Center picks up, delivers message	Same as Navy Message System	Fleet Center records, forwards message	None	None	None	None	None	Same as Navy Message System
10. Technical Problems									
a. EMC Problems	Solved	Solved	Solved	Requires study	Requires study	Requires study	None	Requires study	Solved
11. Ease of Transitioning System to Next Phase	Excellent	Excellent	Excellent	On line satellite required	On line satellite required	Excellent	Excellent	Excellent	Excellent

*Comstar also covers Puerto Rico

Note: SST = Shipboard Satellite Terminal
RT = Remote (land site) Terminal

Table III-II. Performance Comparison

Columns 2 through 10 list the nine systems considered and the performance they would achieve. Each of the criteria will now be described.

a. Installation Requirements

The antennas and other equipment required for the two Navy GapSat systems are already installed on the ship and hence no additional space (except for the OpScan 17 and the teletype) is required. The same is true for a ship system using HF and AUTODIN, as well as a remote land site using AUTODIN.

In the case of the remaining satellite systems, their equipment requirements and the time required for installation are listed.

b. Frequency Band

The frequency band employed by each system is listed.

c. Operational Availability

(1) Geographical Constraints

All DOD systems (Columns 2, 3, 4, 8 and 10) have worldwide coverage. The "footprints" of the remaining systems are included under the description of each system.

(2) Time of Availability

All DOD systems plus those of Columns 7 and 9 are available on a 24-hour-per-day basis. However, the Memphis CMI computer is on a two-shift basis, which is the limiting item regarding availability of these systems. ATS-6 and ATS-1/3 would be available to the project one or two times during the day for a total period of 1-2 hours, a NASA constraint.

d. Maintainability

The DOD and commercial systems provide the best maintainability since they are basically operational systems. Good maintainability is expected from the NASA experimental systems.

e. Transmission System Usage

As indicated in the section on Data Requirements, 30 students taking two hours of training per day will require the equivalent of five to six standard Navy messages (each containing 1,200 characters) per day being sent from the ship and 89 standard messages in reply to the ship. All other systems except the HF/AUTODIN system would require the same transmission times. HF/AUTODIN requires more because of the higher error rate involved (thus more reruns or redundancy for error correction techniques).

f. Message Response Time

The DOD systems have the longest turn-around time (in the order of 1 to 8 hours), with the HF System response time being of the same order but more highly variable due to variable propagation characteristics. The other systems offer the same response time as the current CMI system (12 seconds).

g. Additional Response Time Due to Transmission Error

The demonstration system will not provide any error correction capability. Hence, any detected errors will require a retransmitted service request,[1] requiring an additional response time as indicated previously.

h. Earth Station Path to Memphis

The location of the earth station used by the various satellite systems and the land lines required to complete the path to Memphis are listed.

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[1] This service request will probably consist of repeating the particular CMI messages affected twice with the reply also being sent twice so that a comparison of the three replies can be made. Thus, the error correction will be based on the "two out of three" decision rule.

i. Interruption of Normal Work

The Navy message system alternative requires the CMI Computer Center to pick up the messages from the Memphis TCC, a distance of one mile, and return the replies, two to three times per day. The Navy voice circuit system requires the Fleet Center to record the message, and forward it to Memphis once they set up the voice circuit. They must also repeat the process for the return path. All the other systems require no interruption from the normal work of the CMI computer center personnel.

j. Technical Problems

Any electromagnetic compatibility (EMC) problems to be solved are indicated.

k. Ease of Transitioning System to Next Phase

All of the demonstration system alternatives, except those using the ATS-6 or ATS-1/3, can be readily expanded into an operational system up to the permissible limits of its communications capacity.[1] Thus, their ease of transition is excellent. If the ATS-6 or ATS-1/3 approach were to be operationalized, an on-line satellite would be required, thus taking additional time before an operational system were available.

3. Cost Analysis

Table III-12 is a summary of the costs to be incurred at each element of the total system, as shown in Column 1, for each system alternative considered. Columns 2 through 10 list the various systems

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[1] See Chapter IV for an estimate of the amount of student training which each percent of FleetSatComm could provide. This same type of analysis could also apply to other satellites being considered.

Table III-12. Cost Comparison

(1)	(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)	
System	Navy Message System		Navy Voice Channel System		ATS-1/3		ATS-1/3		ATS-6		ATS-6		Domestic/Commercial Satellite**		ARPA-NET		MARISAT	
Classroom Location	Ship/Land		Ship/Land		Ship		Land		Ship		Land		Land		Land		Ship	
Connection to Memphis	AUTODIN		AUTOVON		Telephone Line		Telephone Line		Telephone Line		Telephone Line		Telephone Line		Telephone Line		COMISAT Provided Telephone Line	
	$(K)	MHRS	$(K)	MHRS	$(K)	MHRS	$(K)	MHRS	$(K)	MHRS	$(K)	MHRS	$(K)	MHRS	$(K)	MHRS	$(K)	MHRS
Ship/Land Site	27.1	61	35.5	76	196.2 - 493.2	591 - 682	66.5 - 93.5	423 - 484	281.5 - 663.5	575 - 666	165.5 - 270.5	423 - 484	175.5 - 285.5	575 - 666	35.5	91	233.1 - 508.1	575 - 666
Satellite Usage	–	–	–	–	–	–	–	–	–	–	–	–	7.7ø	–	–	–	22.8***	–
Earth Station and Land Line	–	–	–	–	2.2	40-76	2.2	40-76	2.2	40-76	2.2	40-76	1.3	–	2.5	–		–
NAVCAMS	–	–	*	160	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CMI Computer Center	70.0 (Software)	304	40 (Software)	–	40 (Software)	–	40 (Software)	–	40 (Software)	–	40 (Software)	–	40 (Software)	–	40 (Software)	–	40 (Software)	–
Memphis TCC	–	–	–	–	–	–	–	–	–	–	–	–	–	–			–	–
Total Cost	97.1	365	75.5	236	238.4 - 535.4	631 - 758	108.7 - 135.7	463 - 560	323.7 - 705.7	815 - 742	207.7 - 312.7	463 - 560	224.5 - 334.5	575 - 666	78.0	91	295.9 - 570.9	575 - 666

øBased on $1,110/month x 7 months

*Requires magnetic tape recorder, available from NETISA

**The Domestic/Commercial Satellites are Westar, (including American Satellite), RCA Satcom, and Comstar

***Based on 15 min./day, 5 days/week for 7 months whose costs are presented.[1] Row 1 lists the system name; Row 2 lists the location of the classroom (ship or land); Row 3 lists the type of communications path required to get to Memphis. Costs are divided into two parts:

- Man-hours of work for the entire demonstration, including pre-demonstration training, for example.
- Dollars of non-manpower expenditures.

Details of the cost elements comprising each of the total costs are contained in the sections describing each system alternative.

As seen, the Navy Message System is the least costly system[2] for shipboard operation because it uses the existing ship satellite terminal. Its only added cost element is the additional software required for the CMI computer including translation of the Baudot code to ASCII and reverse, as well as the addition of a standard header (including date/time group) and trailer to compose the AUTODIN message.

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[1] A separate column for HF/AUTODIN is not included because its basic costs are those of the AUTODIN system as shown in Column 1. However, the CMI computer center at Memphis would need to provide comparisons of the triplicate messages sent from the classroom (one set for every half hour) to keep the HF error problems to reasonable proportions. This added cost has not been determined because the use of HF is felt to be of low probability due to its error characteristics.

[2] As noted elsewhere, the Navy voice circuits are not intended for data transmission and thus could not be expected to be available for uses such as COMISAT.

APPENDIX III-A

LOCATIONS OF DOMESTIC/COMMERCIAL SATELLITE EARTH TERMINALS

Westar Satellite Earth Station Cities
- Los Angeles, California
- Chicago, Illinois
- Dallas, Texas
- Atlanta, Georgia
- New York, New York

Westar Satellite Access Cities
- San Francisco, California
- Houston, Texas
- St. Louis, Missouri
- Pittsburgh, Pennsylvania
- Washington, D.C.

American Satellite Corporation Earth Station Cities
- New York, New York
- San Francisco, California
- Los Angeles, California
- Dallas, Texas
- Fairchild AFB, Washington[1]
- Loring AFB, Maine[1]
- Centerville Beach, California[1]
- Moffett Field, California[1]
- Offutt AFB, Nebraska[1]
- Monterey, California[1]

American Satellite Corporation Access Cities
- Chicago, Illinois
- Atlanta, Georgia
- Houston, Texas
- Pittsburg, Pennsylvania
- Washington, D.C.[2]
- Seattle, Washington[2]
- Philadelphia, Pennsylvania[2]

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[1] Dedicated Military

[2] Filed

RCA Satcom Earth Station Cities
- New York, New York
- Los Angeles, California
- San Francisco, California
- Philadelphia, Pennsylvania
- Chicago, Illinois
- Houston, Texas
- Atlanta, Georgia (under construction)
- Honolulu, Hawaii (possible future station at Paumalu)
- Denver, Colorado (possible future)
- Indianapolis, Indiana (possible future)

RCA Satcom Access Cities
- Washington, D.C.
- Boston, Massachusetts
- Wilmington, Delaware
- Dallas/Ft. Worth, Texas

RCA Satcom Dedicated Government Locations
- Camp Roberts, California
- Greenbelt, Maryland
- Thule, Greenland
- Edwards AFB, California (late 1976)
- Goldstone, California (early 1977)
- Barking Sands, Hawaii (early 1977)
- Paumalu, Hawaii (possible future)
- Dayton, Ohio (possible future)
- Vandenburg AFB, California (possible future)

RCA Alaska Communications Earth Station Cities

In Operation
- None
- Bethel
- Talkeetna (serving Fairbanks and Anchorage by microwave)
- Prudhoe Bay
- Valdez
- Juneau
- Yakatat

To Become Operational in 1976
- Kotzebue
- Barrow
- Dillingham
- Adak
- Yalena
- Unalakleet
- Unalaska

To Become Operational in 1977
- Cold Bay
- Sand Point
- Tanana
- Indian Mountain
- Fort Yukon
- Kodiak
- Shemya

To Become Operational in 1978
- King Salmon
- McGrath
- Hiamna
- Sparrevohn
- Cape Romanzoff
- Cape Newenham
- Camp Lisbourne

Comstar[1]/A.T.&T. Earth Station Cities
- New York, New York
- Chicago, Illinois
- San Francisco, California
- Atlanta, Georgia

Comstar[1]/G.T.&E. Earth Station Cities
- Los Angeles, California
- Tampa, Florida
- Honolulu, Hawaii

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[1] No private lines except to U.S. Government until April 1979.

Chapter IV

COURSE ANALYSIS

A. Introduction

The purpose of this chapter is to discuss the analysis of the Class A-school courses and General Damage Control course that was conducted to determine their possible candidacy for the COMISAT Project. There were a number of criteria developed which served as guidelines for the analysis of the courses. While it is difficult to rank order the criteria in terms of their importance, there are several items which seem more important in terms of the course analysis and subsequent selection of candidate courses for the demonstration. Among these the following criteria are most important to the course selection: the selected CMI course must be operational or, if not, be operational in time for the demonstration; the course cannot exceed 250 1-hour modules, assuming a six-month demonstration period; associated course materials and/or lab equipment necessary for the selected course must conform to the shipboard or remote land site location space requirements; and the training should create minimal interference with site operations. Table IV-1 summarizes the information regarding each of the courses analyzed relative to the above and other criteria.

B. Analysis

1. The Courses

The discussion of each individual course is approached with the following perspectives in mind: whether a shipboard setting or

Table IV-1. Courses Analyzed

Criteria for Selection	Courses								
	BE&E	AFUN	ADJ	AV	RM	GDC	MM	EN	BT
1. Existing/Soon to be operational.	OP	OP	OP	OP	6/77*	CII	OP* FY 77**	OP* FY 77**	OP* FY 77**
2. Concludes with designation as striker.	No	No	No	No	Yes	N/A	Yes	Yes	Yes
3. Minimal interference with site operations.	Yes	No	No	No	Yes	Yes	Yes	No	Yes
4. Cannot exceed 250 1-hour modules.	200 CC120	56-420			336S 270L CC194	30	442 CC127	267 CC127	247 CC127
5. Trains enough personnel to meet demonstration "N" requirements.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Available to students to go partway through course prior to November 1977.	Yes	Yes	Yes	Yes	Yes	N/A	Scheduled	Scheduled	Scheduled
7. Lab equipment conforms to shipboard/remote space usage.	Yes	No	No	No	Yes	N/A	Yes	No	Yes
8. Could be acceptable at demonstration site.	Yes	No	No	No	Yes	Yes	Yes	No	Yes

Legend:

S = Sea
L = Land
CC = Common Core Portion included in the first column number
OP = Operational

*Common Core currently operational
**Estimated operational date

remote land base would be used for the demonstration site;[1] and whether new personnel or existing site personnel would be used for the demonstration. Further, the discussion focuses on the content of each course; why it would be applicable to the demonstration; what the course is oriented toward; and, what equipment or course hardware possibly would be needed. Of the courses listed in the table, five of them are partially or totally operational on the CMI system at the present time; these include BE&E, AFUN, ADJ, AV and the Common Core for BT, MM, and EM.

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[1] Discussion of what might be accomplished at potential sea or land demonstration sites is speculative, since it was not possible to visit any sea or land site.

a. Radioman (RM)

Although not planned for CMI operation until the fall of 1977, the RM course is a likely candidate for the project; however, it is a stronger candidate if new personnel are to be the demonstration subjects, because it may be difficult to muster the number of existing individuals needing A-school RM training, without using several sites.

(1) General Description

The RM course is designed to provide non-rated personnel with the basic skills needed to operate teletype circuits, prepare teletype tapes, and process messages. Further, depending on the operational site to which personnel are to be assigned, the training includes simulated shore or shipboard watch standing. Personnel assigned to ship duty take a track which lasts approximately 336 hours. The land track takes about 270 hours. After basic skill training which lasts six weeks, or about 194 hours, the remaining training time differs between the sea and land assigned personnel, with 4.6 (142 hours) and 3.4 (75 hours) weeks required, respectively.

Basic skills training is divided into seven levels. The levels include:

Level One.....Module 1--Introduction to Security
Module 2--Destruction of Classified Material
Module 3--Organization

Level Two.....Module 1--Introduction to Messages

Level Three...Module 1--Methods of Message Delivery
Module 2--Message Processing

Level Four....Module 1--Incoming Message Flow

Level Five....Module 1--AUTODIN Modified ACP 126 Format
Module 2--Tape Preparation

Level Six.....Module 1--Circuit Operating

Level Seven...Module 1--Message Files
Module 2--Teletypewriting Proficiency
Module 3--Tape Reading

After the basic skill training, personnel assigned to sea duty pick up the Sea Track, which is divided into two phases: Basic Shipboard Laboratories (BSL) and Practical Application Laboratories (PAL). The BSL lasts for two weeks and provides knowledge, skills, and experience required to select, set up, and patch equipment to form shipboard communications systems; test and operate communications systems; isolate faulty equipment within the malfunctioning communications systems; restore malfunctioning systems to normal operation through adjustment or replacement of faulty components; and perform planned maintenance.

Next, PAL or Prac Deck is taken; this final phase is scheduled for 2.6 weeks. The learning approach is application-oriented with students standing six-hour watches in a simulated shipboard environment. The first three watches are evening and the last ten either day or mid-watch. The evening watches are concerned with equipment usages and crypto training while the day and mid-watches apply and test student capabilities in communications procedures and operations.

Personnel assigned to land sites take a Shore Track after basic skills training; it is similar in purpose to the Prac Deck and lasts for the same period of time. The shore laboratory is designed to simulate a shore-based NAVCOMSTA. The students begin with evening watch, which serves to orient them to the equipment and procedures; then they proceed to day watch for the application portion of their training. This is followed by mid-watch where the student is tested. Each watch lasts six hours.

The training materials consist of technical manuals and some AV. The training equipment is operational gear, some of which the trainees will eventually use at their job site.

(2) Demonstration Potential

Since the RM course is still in the development process for CMI, it is not known how much of the existing course can be placed on CMI. For those sections of the course where learning and testing are applications-oriented--and this is a considerable portion of the course--it will require a considerable amount of creativity on the part of the IPD team to CMI them.

Nevertheless, assuming that the total RM course would be on CMI and validated by demonstration time, it would appear that the course could be used for the demonstration. Looking at the course length, which is 336 hours for sea- and 220 hours for land-assigned personnel, at a minimum new Navy personnel probably would be expected to master Basic Skill training before assignment to the demonstration site. Therefore, in both instances the remainder of the course hours would meet the 250 hours or less criteria for use during the Demonstration Phase, since sea-assigned personnel would have 142 hours remaining and land-assigned 75 hours. However, for sea-assigned personnel, there is a strong possibility that BSL Training would be needed before the demonstration subject is acceptable to a ship. Thus, the remaining course time for these individuals also would be 75 hours.

Addressing the space requirement for learning materials and equipment at the demonstration site, the requirement appears to be minimal given that the majority of the last 75 hours remains hands-on training. Under current Prac Deck, the training is site equipment specific; therefore, actual site equipment possibly could be used. This could be handled so that there would be minimal interference with normal operations. Perhaps demonstration subjects could be assigned to normal watches under the tutelage of experienced site personnel as they work through the remaining 75 hours. Increasing responsibility could be assigned as the subjects' learning progresses.

Should a decision be made to use existing site personnel for the demonstration, it will be necessary, of course, to find site personnel who need first-time training in RM. In terms of equipment, the same approach noted above could be used; furthermore, the use of equipment for training by existing personnel may be more acceptable since they are known quantities.

If it would be impossible to use site equipment for the remainder of the RM course training, the course would not be a likely candidate for the demonstration. While a land site may be able to accommodate the additional equipment, the amount required and the expense necessary to obtain, ship, install, maintain, etc., would appear to be excessive. For example, the cost alone for the Multiple Address Processing Unit (AN/FGC-73(V)) is $125,000, and the Digital Systems Telecommunications Equipment (AN/FYA-71(v)2), $500,000.

b. General Damage Control (GDC)

A GDC course is operational in CII (Computer Integrated Instruction) format for a shipboard minicomputer demonstration sponsored by the Navy Personnel Research and Development Center (NPRDC), San Diego. The course could be a candidate for the COMISAT Project if the demonstration site is a ship with a desire to train their existing personnel in the available content.

(1) General Description

The GDC course has been designed to assist shipboard personnel meet the PQS-2 requirements. There are approximately 30 course hours consisting of eight PQS-2 numbers; they include:

2101--Damage Control Theory
2102--Nuclear, Biological, and Chemical (NBC) Theory
2104--Safety Precautions
2203--Firemain System
2206--Fixed Damage Control Equipment System
2207--Portable Damage Control Equipment System
2208--Personnel Protective Equipment System
2210--Oxygen Breathing Apparatus (OBA) System

The content of Damage Control Theory includes compartmentation and watertight integrity, fire and firefighting, battle damage types and battle damage repair. NBC theory is composed of defense nomenclature, personal protective measures, decontamination techniques and NBC agents. Safety Precautions Theory provides information on the handling of a CO_2 extinguisher, use of internal combustion engines, fighting class "B" and "C" fires, and dangers involved with closed compartments. Firemain System includes water washdown system relative to NBC protection or weather decks and magazine sprinkler system for fire protection. Fixed Control Equipment Systems provides information on the fixed CO_2 system, and the twin agent system. Portable Damage Control Equipment System concerns hoses, nozzles and foam equipment; extinguishers; pumps and eductors; and blowers and lanterns. Personnel Protective Equipment System covers protective clothing, Mark V protective mask, CO_2 inflatable life jacket, casualty dosimeter, and pocket dosimeter. Finally, Oxygen Breathing Apparatus includes information on inspection, operation, cleaning, and storage of the OBA.

The course materials include programmed instruction, audio tape instruction, audiovisual instruction, and self-study guides with the majority being programmed instruction and audiovisual instruction.

(2) Demonstration Potential

The use of the GDC course for the demonstration would limit the demonstration to existing personnel and a shipboard site, since except for hull technicians and other selected personnel, GDC is provided on a ship. As far as could be discerned, it is not provided to existing personnel at land sites.

To use the GDC course would require developing the appropriate computer programs for placing the related management portions on the NETISA computer system. Furthermore, it is possible that course material would need to be reviewed by an IPD center and, if necessary, be revised.

The length of the course, approximately 30 hours, is well within the required 250-hour maximum. Therefore, it would easily fit within the planned six-month COMISAT demonstration period. In fact, the short length of the course would permit a number of repetitions over the demonstration period, thus increasing the sample size.

The impact of equipments on the ship should be minimal since all of the necessary gear for this course is part of the normal damage control locker content. Moreover, theoretically, there would be minimal impact on ship operations, since damage control training is supposed to be a part of the normal operational training. The necessary learning materials and AV equipment take up less than a 3'x2'x2' space.

The selection of the GDC course could be useful in that a direct comparison could be made between the NPRDC decentralized computer approach and the COMISAT centralized computer approach for providing computer-managed support for operational training. Such a comparison could yield information about the advantages and disadvantages of each concept.

c. Propulsion Engineering-Boiler Technician (BT) and Machinist Mate (MM)

The Propulsion Engineering course provides training for Boiler Technicians and Machinist's Mates. It consists of a Common Core segment basic to both BT and MM which is followed by 600 and 1200 psi tracks for each area. However, the 600 psi system is being phased out. Only the Common Core modules have been placed on CMI, with the remaining modules scheduled to become operational sometime in FY 77.

(1) General Description

The Common Core modules are designed to provide the prerequisite knowledge and skills necessary to enter BT and MM training where the basic skills necessary for watch standing and preventive maintenance are learned. The total training time for the BT course, including the Common Core, is 247 hours and the MM is slightly over 442. The Common Core takes about 127 hours.

The Common Core content consists of the following:

Module 0--Indoctrination
Module 1--Metal Fasteners and Hand Tools
Module 2--Pipe, Tubing and Fittings
Module 3--Packing, Gaskets and Insulation
Module 4--Valves
Module 5--Bearings and Lubrication
Module 6--Pumps
Module 7--Precision Measuring Instruments and Technical Manuals
Module 8--Heat Properties and Heat Exchangers
Module 9--Indicating Devices
Module 10--Turbines, Couplings and Gears
Module 11--Strainers and Lube Oil Purifiers
Module 12--Low Pressure Air Compressor and System
Module 13--Oil Pollution

It is during this phase of both courses that the majority of the disassemble-reassemble training is accomplished. This occurs in Modules 4, 6, 10, 11 and 12.

As noted above the BT and MM tracks are geared to both the 600 and 1200 psi systems. The former consists of 15 and 20 modules respectively and the latter 16 and 17 modules respectively. Since the 600 psi is being discontinued, the following discussion treats only the content of the 1200 psi BT and MM courses.

Basically, the BT training addresses the system functions and operation of the 1200 psi boilers and supporting components and systems including preventive maintenance procedures. Using the Engineering Operational Sequencing System (EOSS) for the operable Navy Distillate fired 1200 psi (DE-1052 Class), steam propulsion training plant, operation of boilers, fireroom components/systems and casualty control exercises are conducted for each watch station.

The MM course provides training in the system functions and operation of 1200 psi HP and LP turbines and supporting components and systems, including maintenance procedures. The EOSS is used, as in the BT course, to conduct training for each watch station.

The training equipment consists of the 1200 psi propulsion system and related and general component parts. Training materials are primarily technical manuals, PI text and AV.

(2) Demonstration Potential

Except for the Common Core the courses are not on CMI, and although they are scheduled to become operational in the near future, there is some doubt that they will be available for the demonstration. However, if they are ready, would they be candidates?

Since new personnel would be used as demonstration subjects, with the Common Core assumed to be provided before deployment to the demonstration site, the remaining BT course length of 120 hours easily falls within the 250 hours or less time frame for completion. However, the 315 remaining MM training hours would require the lengthening of the A-school training time or the lengthening of the demonstration period. As the courses stand, it is unlikely that existing personnel could be used because of the requirement to disassemble equipment, etc., during the Common Core training.

Relative to the demonstration site, it would appear as though these courses mainly lend themselves to a ship, since few personnel trained in these subjects are found at a single shore base. However, as noted above, if existing personnel were used the Common Core training would appear to create major problems in terms of space for equipment and the interference with normal operations. Of course, this may not be a problem with new personnel, since maintenance training would be provided during the Common Core segment prior to deployment. Thus, there does not appear to be any possibility of degrading the ship's operational efficiency with the remaining training activities. If existing equipment could not be used for training, it would not be possible to use the BT and MM course, because a ship cannot accommodate the volume of equipment that would need to be added. In addition the course length would be extremely excessive for MM training.

It should be noted that, since a fair number of personnel working in the rating have received little or no formal training, CNET has sponsored research to determine if the development of mini-A-school BT and MM courses would be worthwhile. Courses were conceptually designed; however, as far as we can determine, they have not been put into operation. They possibly could be prepared for the demonstration, but would require the development of the course materials and the placement of the administrative component on the NETISA computer system at Millington, Tennessee.

d. Diesel Engine Maintenance Training--Engineman (EN)

The Diesel Engine Maintenance Course provides training for Enginemen relative to diesel maintenance and diesel propulsion plant watch standing. The Common Core Course used for BT and MM is also used for EN. Training time excluding Common Core is 140 hours, 267 hours with Common Core.

(1) General Description

Basically EN training treats all maintenance aspects of the 6-71 series diesel engine. Component parts are identified along with their functions and care. Personnel also are trained to disassemble and reassemble the engine. Further, using the EN school laboratory EOSS for the 8-268A diesel propulsion engine controllable pitch propeller system, supporting auxiliary componental systems and casualty control exercises are conducted.

The learning materials used for the course are technical manuals, AV aids, student notebook and some PI texts. As noted above, the required equipment includes a 6-71 series diesel engine and a 8-268A diesel propulsion engine. Selected component parts are also used.

(2) Demonstration Potential

Like BT and MM the total EN course is not now on CMI. Although scheduled to become operational in the near future, there is some doubt that it would be available for the demonstration.

Assuming the course were available, if existing personnel were used as demonstration subjects, its 267-hour length would require the lengthening of the demonstration period. However, if new personnel were used some portion or all of the Common Core segment could be taught before deployment to the demonstration site, thus bringing the remaining course length within the demonstration period. Relative to a demonstration site, it would appear as though the course mainly lends itself to a ship, since the majority of the rate is found there.

The totality of the training probably could not be provided aboard ship due to the requirement for disassembling and reassembling of equipment during the Common Core and in an initial module of the maintenance training segment; consequently, EN training would possibly degrade the operational efficiency of the ship. Therefore, it does not seem likely that existing personnel could be used as demonstration subjects. New personnel are more likely candidates since they could be trained at the A-school through the "disruptive" modules and then be deployed to complete their training at the demonstration site.

e. Basic Electricity and Electronics (BE&E)

BE&E is an operational CMI course, providing training for a large number of ratings. The training is tailored to the requirements of the rate with the length varying accordingly. There are 34 modules, with the first 14 being considered common core modules. They provide the skills and knowledge necessary for the rate-related training that follows.

(1) General Description

The basic modules consist of:

Module 1--Electrical Current
Module 2--Voltage
Module 3--Resistance
Module 4--Measuring Current and Voltage
Module 5--Relationships of Current, Voltage, and Resistance
Module 6--Parallel Circuits
Module 7--Combination Circuits and Voltage Dividers
Module 8--Induction
Module 9--Relationships of Current, Counter EMF and Voltage in LR Circuits
Module 10--Transformers
Module 11--Capacitance
Module 12--Resistive-Reactive Circuits
Module 13--Circuits and Resistance
Module 14--Resistance and Reactive Circuits

There are 12 major ratings that receive BE&E related training: Torpedoman's Mate, Construction Electrician, Communications Technician, Electronics Technician, Electronics Warfare Specialist, Sonar Technician, Gunner's Mater, Interior Communications Electrician, Fire Control Technician, Radioman, Data Systems Technician, and Electrician's Mate.

The following are examples of time needed to complete training for specific rates. The Internal Communications Electrician (IC) requires a total of 260 hours for completion through the 25th module; Radioman (RM) requires a total of 200 hours for completion through the 21st module; Electronic Warfare (EW) takes 215 hours; Electronics Technician (ET) 120 hours; and Gunner's Mate Technician (GMT) 111 hours.

The learning materials used for the training are made up of PI booklets and audiovisual aids; the laboratory equipment includes electronic test equipment such as volt and ohm meters, and oscilloscopes and, of course, the actual or simulated devices on which the test equipment is used.

(2) Demonstration Potential

As noted above, the BE&E course is on CMI, and it has been thoroughly tested for over three years; therefore, using the course for the demonstration would be a simple matter.

The course length does not appear to be excessive because most rate training falls within the 250-hour length imposed for the demonstration. If the demonstration subjects are to be new personnel, and the Common Core were to be taken prior to deployment to the demonstration site, in all cases the remainder of the BE&E training would be less than 100 hours. Should existing site personnel be used, in the majority of the ratings the total course length is within the 250 hours.

While the BE&E course appears to have a potential for use in the demonstration, it is basically a prerequisite course. In other words, BE&E is taken prior to receiving rate-specific training; consequently, additional A- or C-school training is required prior to deployment. Thus, it is highly unlikely that if new personnel were used for the demonstration, the course would be of value. Should existing site personnel be used for the demonstration, the course possibly could provide basic training for those individuals who have not taken BE&E and wish to now or personnel who wish to start initial training for a new rate.

From observation and discussions with personnel at Orlando, Florida, and Millington, Tennessee, about the BE&E course, the training materials and equipment would appear to take up a minimal amount of space. In fact, the space requirement needed for materials and equipment to support the training of 30 subjects would appear to be no greater than 16"x40"x72". Because the training would not necessarily need to transpire using operational equipment, no interference with the operation of the demonstration site is anticipated.

f. Aviation

Three Aviation courses are currently operational on CMI. The possibility of using Aviation Fundamentals (AFUN), Aviation Machinist Mate (ADJ), or Avionics (AV) was discussed with personnel at Millington. It was pointed out that due to the necessity for all A-school Aviation personnel to take C-school or FRAMP to gain hardware specific training, the courses would not be viable for the demonstration. Placing personnel aboard ship without being totally trained is considered hazardous to the individual as well as other crew members.

2. Courses and Potential Demonstration Sites

In order to place the courses in perspective, an analysis was conducted of possible demonstration sites relative to the number of billets in the SN and 3 levels within rates. It was assumed that such information would provide some insight into whether new personnel might be absorbed, as well as the possible number of existing individuals who might need A-school training. In terms of the latter, it may be that the SN level probably has the greatest potential for needing basic A-school training.

Data were gathered on 52 U.S. Navy remote land sites, but limited to two representative ships, an aircraft carrier and a missile cruiser. Table IV-2 shows the information gathered for the remote land sites. Table IV-3 shows information for the USS Ranger and USS Chicago. For each site the total number of billets assigned is shown along with the number of billets in the SN and 3 levels within the rates.

The RM rate has the greatest number of billets at the various land sites with 352 and is second to MM on board the two ships analyzed. In terms of the number of RM's at the SN and 3 levels, the remote land sites have 137 and 226, respectively, and 49 and 42, respectively, on

Table IV-2. Course Analysis for Remote Land Sites[1]

Site	Rate[2]—Level SN or 3												
	BT	CT	DS	EN	ET	EW	FT	GM	IC	MM	RM	ST	TM
Bermuda Islands (759)	2	0	3	0	0	0	0	0	0	1	15	0	0
Bermuda Islands, Kindley AFB (42)	0	0	0	0	0	0	0	0	0	0	2	0	0
Iceland, Keflavick (966)	1	0	4	0	0	0	0	0	1	0	16	0	0
Azores, Lajes Field (166)	0	0	0	0	0	0	0	0	0	0	23	0	1
Leeward Islands, Antigua (102)	0	0	0	0	0	0	0	0	0	0	12	0	0
Barbados, Speightstown (96)	0	0	3	0	0	0	0	0	0	0	12	0	0
Bahamas, Eleuthera Isl. (129)	0	0	0	0	0	0	0	0	0	0	14	0	0
Cuba, Guantanamo Bay (1,727)	9	0	1	4	0	0	0	0	1	4	40	0	5
Puerto Rico, Roosevelt Islands (1,550)	0	0	0	4	0	0	0	0	1	0	7	0	2
Turks Island (102)	0	0	0	0	0	0	0	0	0	0	11	0	0
Sardinia, La Maddalena (115)	0	0	0	2	0	0	0	0	0	0	0	0	0
Sicily, Sigonella (1,032)	0	0	0	0	0	0	0	0	0	1	0	0	6
Canada, Newfoundland, Argentia (319)	0	0	3	0	0	0	0	0	0	0	16	0	0
Canal Zone, Rodman (64)	0	0	0	0	0	0	0	0	0	0	2	0	0
Guam, Agana (1,179)	0	0	0	15	0	0	0	0	0	5	20	0	10
Midway Island (758)	1	0	0	3	0	0	0	0	1	0	30	0	0
Bahrain, Manama (84)	0	0	0	0	0	0	0	0	0	0	8	0	0
Japan, Honshu Atsugi (525)	3	0	0	0	0	0	0	0	0	7	17	0	0
Japan, Okinawa, Kadena AFB (474)	0	0	0	2	0	0	0	0	0	1	33	0	7
Japan, Honshu, Kami Seya (74)	0	0	2	0	0	0	0	0	0	0	5	0	0
Japan, Honshu, Misawa AFB (341)	0	0	0	0	0	0	0	0	0	1	11	0	6
Japan, Kyushu, Sasebo (94)	0	0	0	0	0	0	0	0	0	0	1	0	0
Japan, Honshu, Yokosuka (728)	0	0	2	2	0	0	0	0	1	0	6	0	8
Korea, Chinhae (29)	0	0	0	0	0	0	0	0	0	0	7	0	0
Korea, Seoul (27)	0	0	0	0	0	0	0	0	0	0	4	0	0

Table IV-2 Continued[1]

Site	Rate[2]–Level SN or 3												
	BT	CT	DS	EN	ET	EW	FT	GM	IC	MM	RM	ST	TM
Luzon, Cubi Point (1,092)	8	0	0	1	0	0	0	0	1	12	9	0	5
Philippine Islands, Subic Bay (1,082)	0	0	0	22	0	0	0	0	0	2	8	0	15
Thailand, Tapao (30)	0	0	0	0	0	0	0	0	0	0	3	0	0
Taiwan, Taipei (123)	0	0	0	0	0	0	0	0	0	0	1	0	0
Italy, Naples (415)	9	0	2	3	0	0	0	0	0	10	0	0	0
Spain, Rota (1,075)	1	0	0	8	0	0	0	0	1	5	0	0	1
Wales, Brawdy (269)	0	0	0	6	1	1	0	0	0	0	17	0	0
Scotland, Holy Loch (253)	1	0	0	8	0	0	0	0	2	4	0	0	0
England, Northwood (7)	0	0	0	0	0	0	0	0	0	0	2	0	0
Total (15,828)	35	0	20	80	1	1	0	0	9	53	352	0	67

[1] Alaskan and Hawaiian sites are not included.

[2] Key: BT–Boiler Technician
CT–Communications Technician
DS–Data Systems Technician
EN– Engineman
ET–Electronics Technician
EW–Electronic Warfare
FT–Fire Control Technician
GM–Gunner's Mate Technician
IC–Internal Communication Electrician
MM–Machinist Mate
RM–Radioman
ST–Sonar Technician
TM–Torpedoman's Mate

Table IV-3. Course Analysis for Two Representative Ships

Ship	Rate–Level SN or 3												
	BT	CT	DS	EN	ET	EW	FT	GMG	IC	MM	RM	ST	TM
U.S.S. Ranger	33	0	3	35	0	7	0	17	16	68	57	0	0
U.S.S. Chicago	16	0	4	10	0	6	0	5	6	25	34	0	1

board the two ships. The land sites with the greatest number are Guantanamo Bay, Cuba, 40, with 23 SN's; Okinawa, Japan, 33, with 12 SN's; Midway Island, 30, with 13 SN's; Azores Lajes Field, 23, with 4 SN's; and Guam, Agana, 20, with 8 SN's. Consequently, from the numbers and the previous analysis, it would appear as though there may be a greater need for RM A-school training by existing personnel, as well as the potential for absorbing new personnel at one or more sites.

The EN rate is second in total billet numbers of SN's or 3's at remote land sites with 81; however, only two sites have more than 8: Subic Bay, Philippine Islands, with 22; and Guam, Agana, with 15. In terms of levels, all are 3's. On board the ships there are 44, with 34 being on the USS Ranger. All are 3 level. Because of limited numbers of EN's at the various sites, particularly in light of the shortage of SN's, and based on the previous discussion, the EN course probably would not be a good candidate for the demonstration.

The Torpedoman (TM) rate has the next greatest number of personnel at remote land sites with 67, but only one aboard the two ships. Like the EN rate there are only two sites with greater than eight individuals at the SN or 3 levels. Subic Bay has 16 and Guam 10. Due to their limited number, and because the BE&E is only part of the initial training, TM rate training probably should not be considered in selecting a demonstration site. This is also true for the CT, DS, ET, EW, FT, GM, IC, and ST rates, for which there is a total of 31 billets at the SN and 3 level.

This is also the case for the BT and MM rates if a land site is being considered. There is a total of 35 and 53, respectively. Relative to BT, no land site has more than nine billets at the SN or 3 levels. And, there are only two such sites, Guantanamo Bay, Cuba, and Naples, Italy. Looking at MM, just two sites have ten or more billets; Luzon, Cubi Point, Philippines, has 12; and Naples, Italy, 10. A ship demonstration site has greater potential for BT and MM training. The

Ranger shows 33 BT's and 68 MM's, with the Chicago having 16 BT's and 25 MM's. However, in both cases, neither ship has an individual at the SN level.

The land sites with greatest potential for the demonstration are associated with the RM course. They include Guantanamo Bay, Okinawa, Midway Island, Azores, and Guam, with 20 or more billets in the rate. It is possible that one or two sites could satisfy the required sample size if existing personnel were to be the demonstration subjects; more sites may be required if new personnel are the subjects. The best site for the BT and MM courses would be a ship.

C. Conclusions

The RM course appears to be the best suited for the demonstration. With it, the demonstration site could be a land base or a ship and the subjects could be new or existing personnel. If the ship is interested in a course that will aid in the improvement of its operational effectiveness, the GDC would appear to be applicable; however, it is not presently on the CMI system.

While the BT and MM courses also are possible candidates, except for the Common Core they are not on the CMI system and may not be completed before the proposed November 1977 demonstration initiation date. Nevertheless, they would be best suited for a shipboard demonstration site and are presently geared to new personnel.

Finally, it should be remembered that the above analysis was related to billet assignment in the SN and 3 levels and does not necessarily reflect the actual number of individuals assigned or actually needing training.

Chapter V

DEMONSTRATION OBJECTIVES AND RELATED MEASURES

A. Introduction

In this chapter, each demonstration objective is examined in general terms to determine its practicality relative to operational measurability and data recordability. For the purpose of the discussions which follow, the term "objectives" refers to those objectives established at the outset of the COMISAT demonstration project; "measures" refers to variables which operationalize the objectives and should be recorded; and "instrumentation" refers to methods for recording the data and information.

B. Objective 1

Objective 1 is to determine whether CMI delivered to remote sites produces the same learning effectiveness as CMI does in the learning center environment.

1. Measures

Two measures seem to be of primary importance. Since all students must achieve certain criteria, the time taken to meet the criteria is a key dependent variable. Furthermore, in those cases where the criteria requirement is not 100 percent, the test scores in excess of criteria also are key dependent variables, although they must be wedded to time.

In order to determine the impact of the training environment (schoolhouse vs. operational site) on time taken to complete course modules, it would be necessary to obtain the following information on the control and experimental groups and make comparisons.

- Student Response History--Status Report
- Correlation matrix between I.Q., length of time to complete course and G.C.T. data
- Original predicted time to complete module
- Adjusted predicted completion time for each module
- Actual completion time for each module
- Test scores--final module and individual tests

To make the comparison of test scores in excess of criteria, it would be necessary to collect all module test score data for the control and experimental groups.

2. Instrumentation

The data relative to time to complete and test scores are readily available through the CMI system. "Time to complete" a course or a module within a course is automatically calculated for each student based on his Basic Test Battery Score. This information, as well as student test scores, is recorded as part of the class file. Therefore, new instrumentation would not be required for collecting these data. Rather, requests for printouts or tapes of the information would need to be submitted to NETISA.

3. Intervening Variables

Related to measuring Objective 1 is the student reading skill. An NPRDC study[1] by Aiken, Duffy, and Nugent indicates that "reading skills and nonverbal ability are as good or better as predictors of school performance as course selector tests in some schools." Two important conclusions of the study seem appropriate as a justification for this data collection:

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[1] See NPRDC Technical Report Number TR-76, September, 1976.

- Reading skill as measured by the Nelson-Denny Reading Test is generally lower for attrited students than for successful trainees.
- Reading skill tests were generally better predictors of success than were course selector tests for many of the Class A-school courses used in the study.

Therefore, once a course is chosen for the demonstration, an analysis of the reading grade level for course manuals and a test of subject reading skills should be conducted. Variations of the Flesch readability formula[1] could be used to determine the reading grade level of the materials for the selected demonstration course, and the Nelson-Denny Reading Test could be used to determine the reading skill levels of the students selected as subjects for the demonstration.

Several other intervening variables should be taken into account and treated as covariates. These may include the student's prior education and some of the information provided by the Basic Test Battery Scores, such as:

- General Classification Test Score
- Shop Practice Score
- Arithmetic Aptitude
- Mechanical Ability
- Clerical Ability
- I.Q.

In summary, there appears to be no problem in identifying measures or collecting the related information for Objective 1. Almost everything required is part of the CMI system data base.

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[1] CNETS Report 2-75, "Reading Grade Levels of Navy Rate Training Manuals and Non-Resident Career Courses," pp. 9-18 and 21-26.

C. Objective 2

Objective 2 is to determine whether the attitudes of students, trainers, and key remote site personnel are supportive of CMI delivered to remote sites.

To determine whether attitudes are supportive of the CMI delivered to remote sites, attitude measures would need to be defined for three main groups:

- Students participating in the actual demonstration
- Learning supervisors at the demonstration site
- Key demonstration site personnel

There are two ways to obtain attitude information. One is to observe overt behavior; the other is to solicit verbal or written expressions. While a combination of the two is desirable, it is highly unlikely that it would be possible to monitor the overt behavior of the demonstration subjects because of their numbers and the limited number of overt behavioral expressions that might conceivably be associated with attitudes about the CMI system per se. This also would be true for the instruction and key shipboard personnel. Nevertheless, it may be prudent to attempt to define a limited list of behaviors for each group that may be indicative of their attitudes, even though it may not be possible to statistically correlate the behavior with the CMI system. Consequently, if these behaviors cannot be attributed to other causes, with caveats, they might be interpreted to be related to the CMI system.

The most direct and probably the most productive approach would be to solicit verbal and written expressions relative to the CMI system, associated activities, objectives, etc. Furthermore, it would be necessary to determine if there are intervening variables that might be influencing the behavior of the participants.

1. Measures

a. Student

In terms of the CMI concept, student attitude data/information should be collected in two categories: the CMI system functions and the learning supervisor. Only three aspects of the CMI system functions would be readily apparent to the student: input via the OpScan; system feedback relative to time; and the content of the feedback. In all three cases, a determination should be made of their usefulness and adequacy. Concerning the learning supervisor, the students should be queried about the value of the concept and the utility of such an individual. In terms of the intervening variables that might be influencing demonstration subject behavior, some insight into morale, motivation and self-concept would appear to be necessary.

b. Learning Supervisor

Important input would be learning supervisor and perhaps site training officer attitudes toward the CMI system as well as toward the students. A key factor would be their point of view about the value of CMI as a training support system in an operational environment. Measures with which this might deal could be whether it saves work, or perhaps provides the desired information in light of the environment.

It is extremely important to collect information about the perception of instructional personnel vis-a-vis the demonstration subjects. The instructor's attitude toward the students in his classroom often plays a key role in determining how the students do in the program. Hence, instructor attitude toward students may be an important covariate in the study. In classical terms, the effect that an instructor's attitude toward his student has on that student's performance is often referred to as the "Pygmalion effect." The theory is that if an instructor is led to believe or believes that a student has certain intellectual abilities, regardless of whether the student has these abilities or not, the student will tend to perform in that manner. Therefore, it would appear to be important to determine what attitudes the instructor(s) holds toward the general body of students that he would be working with during the demonstration phase of the project.

c. Site Personnel

Finally, since the integrity and efficiency of the CMI system also depends upon the attitude of key remote site personnel, information should be collected on their perceptions of and support for the system. The measurement dimension might include whether it was disruptive, led personnel to "goof off," improved morale, etc.

2. Instrumentation

Several instruments exist which may be useful in collecting these measurement data. The first is the approved "Navy Human Resource Management Survey".[1] Its intent is to obtain information related to organizational development. The primary factors listed include leadership, equal opportunity, race relations, training and utilization of people, motivations and morale, good order and discipline, communications, concern for people, drug and alcohol abuse, and interaction with peoples of other countries. While not all of these factors are important to the demonstration, several do seem important; specifically, motivations and morale and communications may provide the desired information. However, what is more important about the survey form is that it contains space for some additional thirty questions, which may be added with the approval of the commander of the site being surveyed. Consequently, it may be possible to use an approved questionnaire to gain the desired attitude information.

Another survey/questionnaire which might be used is the "Job Diagnostic Survey"[2] developed by the Navy. The questionnaire was developed for several ratings in the ASW division with the primary purpose of aiding the Navy in obtaining information which would permit "maximizing the use of new equipments in the shortest time frame possible." While the primary purpose of the instrument does not serve demonstration needs, the instrument does tap information relative to motivation, self-concept and morale and would be useful to that extent.

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[1] BUPERS 5314-6, Research and Evaluation Division, PERS-65, OPNAV Inst. 5300.6B.

[2] LaRocco, J. et al., "Organizational and Environmental Factors in Health and Personnel Effectiveness: II Data Collection Methods, Test Instruments, and Criterion Variables," Report #75-9, Naval Health Research Center and Bureau of Medicine and Surgery, Department of Navy.

Another possible way of collecting these data would be to create a series of evaluative semantic differential scales for student, learning supervisor, and key site personnel attitudes. Preliminary factor analytic work has already been done on some nine different dimensions of morale by Scott (1967). The semantic differential technique originally developed by Osgood, Suci, and Tannenbaum (1957) taps the attitude dimension by using a series of bipolar adjectives which were coined "evaluative" through extensive factor analytic procedures. For example, the personnel could be asked to rate the concept of CMI using the scale shown in Figure V-1.

WE ARE ASKING YOU TO RATE YOUR FEELINGS TOWARD
THE CONCEPT OF CMI ON A SERIES OF DESCRIPTIVE
SCALES. HERE IS HOW TO USE THE SCALES . . .

COMPUTER MANAGED INSTRUCTION

GOOD _____ : _____ : _____ : _____ : _____ : _____ : _____ : BAD
VALUABLE _____ : _____ : _____ : _____ : _____ : _____ : _____ : WORTHLESS
IMPORTANT _____ : _____ : _____ : _____ : _____ : _____ : _____ : UNIMPORTANT

Figure V-1. CMI Rating Scale

There have been a few instruments developed for supervisors but their primary purpose does not coincide with the nature of this operational variable. For example, the Enlisted Utilization Survey (supervisor form) does determine a few attitudes of the instructor toward his students, but the items in the survey do not tap significant evaluative dimensions (see BUPERS 5314-17).[1] For this reason, attitudes probably would be best operationalized by creating the semantic differential scales.

It appears that the most feasible approach to data collection under this objective would be a combination of all three methods. Of the three, the one that has the most merit is the "Navy Human Resource Management Survey," the primary reason being that it is already in the Navy system and has been approved by BUPERS for fleet usage. Also, it has received considerable developmental effort and/or validation at the present time and has been developed in the automated scanning answer sheet format.

In concluding this discussion, it is important to note that a significant constraint related to any proposed attitudinal data collections may presently exist. It has been indicated that a moratorium has been placed on attitude and motivational surveys at the direction of the Chief of Naval Personnel. If this moratorium were lifted, an additional related constraint would also pose some difficulty. This constraint binds the data collector to avoid identifying the site from which the data has been gathered. The obvious solution to the constraint is to have more than one site involved in the demonstration. Further, it would also be important to insure that no individual student be identified by name in the results of the project. The details of this concern are outlined in NAVPERSRANDCEN INSTRUCTION 5211.1 and are pursuant to Public Law 93-579 (the Privacy Act of 1974).

D. Objective 3

Objective 3 is to determine whether CMI delivered to remote sites is as economical as CMI in the learning center environment.

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[1] BUPERS 5314-17; DDM (OT) 7462.

1. Measures[1]

To conduct a complete economic analysis of all CMI system alternatives would require measures on three components of the CMI system: the EDP subsystem, communication subsystem, and instructional subsystem. More specifically, measures would be needed within each on operations, maintenance and system support relative to equipment, materials and supplies, personnel and facilities.

For these system entities, data--all converted to dollars--would be needed in the following general categories: number of equipment and spare parts required to initiate an operational system of a given capacity; related start up resources such as hardware and software development, acquisition, installation, and training; additional personnel, facilities, materials and supplies. Next, operating resources would need to be collected for a given period of operation; these include learning supervisor workload, communications operator workload, maintenance workload, support service workload, and supplies and materials expended. Finally, data relative to students would have to be collected to include students taking courses, instruction time each day, instruction time required for the course, student OpScan usage, student attrition, and student costs such as transportation and living expenses while traveling. As the above limited listing suggests, the measures to determine the cost benefit analysis of alternative CMI systems are extensive and there could be some difficulty in obtaining all of the required data.

2. Instrumentation

Data for the economic analysis would need to come from the demonstration per se and from existing sources. Except for the maintenance area system and student information recorded by the CMI system, the data required from the demonstration are not usually collected; thus, special instrumentation would need to be developed. For example, manhours expended by all types of personnel would need to be recorded in special logs. Furthermore, nondemonstration data such as certain types of costs would need to be pursued at various sources throughout the Navy including such locations as BUPERS, NETISA, CNTECHTRA, and so on.

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[1] For a detailed discussion of measures as they relate to the economic analysis model see Chapter VII.

The measures to conduct the cost benefit analysis of alternative CMI systems are extensive. Furthermore, as a whole, considerable instrumentation would need to be devised to record the required information and data elements. Consequently, there could be considerable difficulty in realistically operationalizing the objective, as well as collecting the desired information.

E. Objective 4

Objective 4 is to determine the personnel requirements.

1. Measures

Determining personnel requirements for an operational CMI system has two dimensions. The first measure treats the role and functions of personnel vis-a-vis the system; the second addresses the numbers of individuals required for the particular roles.

In the first instance, for each individual directly involved in the demonstration or indirectly impacted by the system relative to new job tasks, a descriptive characterization of that individual's new job tasks would need to be delineated. In addition, it would be necessary to determine whether normal job task execution is increased or decreased as a result of the CMI system.

Concerning the second measure, data would need to be collected on the amount of time individuals spend executing their CMI-related tasks. Based on the time requirements, it then would be possible to calculate the number of individuals required to perform the tasks. It also would be necessary to derive the number of individuals required to work with an operational system by postulating various numbers of students involved in CMI training at job sites and extrapolating required number based on student load. As the discussion of Objective 3 suggests, this information also would be needed for the economic analysis.

2. Instrumentation

Both measurement dimensions of personnel requirements are not normally collected; therefore, instrumentation would need to be developed. Relative to roles and function, the data could be collected through interviews and observation; and to structure the information for comparative purposes, a task analysis could be performed. Descriptions and task information for current jobs exist in some form, but a task analysis possibly would be required so that parity exists for the comparative analysis.

To collect the information on time spent on CMI tasks would require the development of some type of data collection instrument such as a time log. Each individual would be required to record the time period spent involved with the CMI system. As noted above, information concerning numbers of support personnel required would be derived from the time data by postulating numbers of students involved.

In sum, the objective could be operationalized, but instruments would need to be developed for collecting the needed information. A possible major problem area could be the actual collection of time data if personnel would be required to keep track of their own time.

F. Objective 5

Objective 5 is to determine the personnel training requirements.

1. Measures

The measures for the personnel training would result in part from the work accomplished for Objective 4. Of major interest would be the new tasks that would need to be performed and whether they are additions to tasks already performed or would require new personnel. Of course, the time needed to execute the tasks would, as noted above, indicate the numbers of individuals required. For example, it would be necessary to monitor the training supervisor tasks and execution time and to relate the results to the current tasks, etc., of the site training officer or whoever has the primary responsibility for training. If the individual would be required to execute additional tasks or if new people would be required to perform the tasks, training programs would need to be established. Thus, the task analysis and time data from Objective 4 are the primary measures needed for Objective 5.

2. Instrumentation

The basic instrumentation requirement would be the same as for Objective 4. However, it should be kept in mind that the information would be used to define the training requirements for personnel who would work directly with the CMI system or who would interface with it in some fashion.

In terms of the viability of the objective, it is, of course, dependent on Objective 4. If the data is obtainable, then there would be no problem in defining the training requirements.

G. Objective 6

Objective 6 is to determine the organization and management structure required.

1. Measures

Operational sites have well-defined management and organizational structures and policies for executing the work for which they have responsibility. The provision for computer-based support for training via telecommunications could impact many aspects of the structure, policies, and, as noted above, the specific tasks that personnel perform.

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Benchmark data would need to be collected on the management and organizational structure and policies as they relate to current operations and related training. Further, information would be needed on training schedules, approaches and time; and information would need to be collected for key site and other U.S. Navy policy personnel on how CMI would impact current operations and policies given three possible conditions that could exist:

- Personnel fresh out of bootcamp are sent to sites for total training under the management of CMI.
- Personnel are partially trained at A- or C-school and then receive the remainder of their training at their assigned job site under the management of CMI.
- Existing site personnel under the management of CMI can take whatever training desired or required.

2. Instrumentation

These types of data and information are not normally collected; therefore, no instrumentation exists for their collection. Benchmark data could be collected by obtaining whatever exists, and by conducting interviews. Relative to interviews, structured interview approaches probably would need to be developed to insure that the desired information would be collected.

In terms of the impact of CMI on job site operations, the required data would again need to be collected through interviews, and some from observation. More specifically, the demonstration per se would yield some observable manifestations; but to obtain the information concerning the three conditions noted in the Measures section, questions would need to be asked of key site and other U.S. Navy personnel, with a major information source being BUPERS. An input to this data collection effort also would undoubtedly come from the work conducted for Objective 4, since it would provide insights into new job tasks, etc., which would directly affect the management-organizational structure and associated policies.

In sum, the measures for Objective 6 are straightforward, but with the exception of benchmark data which would be readily available, it would be necessary to conduct interviews as well as develop data collection instruments to obtain observable data during the demonstration. Information from Objective 4 would provide some input.

H. Objective 7

Objective 7 is to determine the space requirements and operational procedures for effective use of a CMI training support system.

1. Measures

If the CMI training system has the potential for being operational, there would be a requirement for space to accommodate the equipment and students and a need for procedures to take care of the student load and insure efficient and effective utilization of the system. Therefore, during the demonstration it would be necessary to determine the student loads that equipment would be able to handle, the space needed to store equipment and learning materials, and the area needed for study.

The use of the system by large numbers of students will require proper scheduling for counseling, use of equipment and materials, use of study areas, testing, and providing student feedback on test results. This all becomes somewhat more difficult in an operational setting since CMI support training would be integrated in some manner with normal work hours. Furthermore, since a centralized computer supports training, a more controlled and rigorous approach to operational training would be possible. Consequently, it would be essential to obtain information that would provide insight into the possible site training procedures associated with CMI support.

2. Instrumentation

As a starting point, the information needed for Objective 7 could be collected by tapping the A-schools currently using the CMI systems. They have established space requirements and procedures for handling large numbers of students; however, the information obtained from them would need to be kept in context. Information directly related to operational sites would need to be collected during the trial run and operational phases of the demonstration. Questions would need to be asked of students and key site personnel to determine the problems they have encountered and their views on how the use of the system could be optimized in an operational environment. Thus, the structured interview would be the major data collection approach.

In summary, determining the space and procedures for efficient and effective usage of the CMI training support system appears to be possible. Benchmark information would need to come from existing A-school operations, but a considerable amount of information would be obtained from procedures established for the demonstration and from interviews with key site personnel and students.

I. Objective 8

Objective 8 is to determine the equipment, maintenance, spare parts and logistics requirements.

1. Measures

The final objective addresses the support requirements for the system. The measures are numbers of equipment, e.g., OpScan, 35mm slide projection; the breakrate, associated number of spare parts, and maintenance hours required; and the overall support requirements to keep the system operational. These are standard measures currently collected at the CONUS CMI-supported schoolhouses. However, where necessary, the specific information collected would need to depict the unique requirements of the operational environment. To determine operational requirements relative to "X" number of sites and personnel using the system, certain assumptions need to be made and extrapolations made accordingly. It should be remembered that these data also would be collected relative to Objective 3.

2. Instrumentation

As noted above, the information needed here is normally collected for CONUS sites; therefore, instrumentation does exist and would need only to be put into use at the demonstration site.

In sum, the measures for Objective 8 are operational and the instrumentation does exist.

J. Conclusion

In conclusion, all objectives appear to be realistic in that measures can be defined for each and a means exists or can be devised for collecting most of the data. However, care would be needed in developing data collection approaches for all except Objective 1. Objective 3 could be the most difficult to achieve in toto because of its comprehensiveness and because certain data elements could be unobtainable.

Chapter VI

DEMONSTRATION RESEARCH DESIGN AND EVALUATION FACTORS

A. Introduction

This chapter focuses on the behavioral research that would need to be undertaken to achieve the purpose and objectives of the project. The first section addresses the research design elements, specifically, the alternative experimental designs. The second section treats the design procedures and potential problem areas.

B. Research Designs

The discussion of research design models is based on: a review of current literature relative to communications satellite demonstrations and experiments; a U.S. Navy information search in concert with CNET personnel; and a consideration of numerous design alternatives presented in Campbell and Stanley's Experimental and Quasi-Experimental Designs for Research (1963), Edwards' Experimental Design in Psychological Research (1968), and Kerlinger's Foundations of Behavioral Research (1964).

The illustrations below depict the two research design options that seem best suited for the proposed demonstrations.

- The first design option is a traditional pretest/posttest control group design where random assignment of subjects to research conditions is assumed:[1]

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[1] For a detailed discussion of this design, see Campbell and Stanley's Experimental and Quasi-Experimental Designs for Research, pp.13-24.

Group A RO_1 X O_2 Part schoolhouse, part remote site

Group B RO_3 O_4 All schoolhouse

where R = random assignment of S's

O = observation (test or survey)

X = experimental treatment

- The second design option is for use in the event that it is not possible to have random assignment of subjects to experimental and control treatments. This option, the non-equivalent control group(s) design, is depicted as:[1]

  Group A O X O

  Group B O O

  Here, the treatment is random assignment to groups. This design is often referred to as an "intact" group design. Should this design be used, attention needs to be devoted to the fact that the experimental and control group(s) cannot be necessarily assumed to be equal.

These two designs are discussed below in an operational context.

C. Operational Designs

1. Design 1

Three design approaches are presented. One is considered ideal, the second plausible, and the third most practical.

a. Ideal Design

Figure VI-1 illustrates the ideal design. This design would permit generalizing the results to both remote land and sea sites and would take into account differences which could occur because the experimental subjects would be trained partially on land and partially at sea. In effect, there would be two demonstration bodies, one representing sea sites and one representing land sites. Each body would be comprised of three randomly selected component groups with 30 individuals in each group. One of the groups in each body would be designated a control group for sea (S_c) and

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[1] See Campbell and Stanley, pp. 47-50.

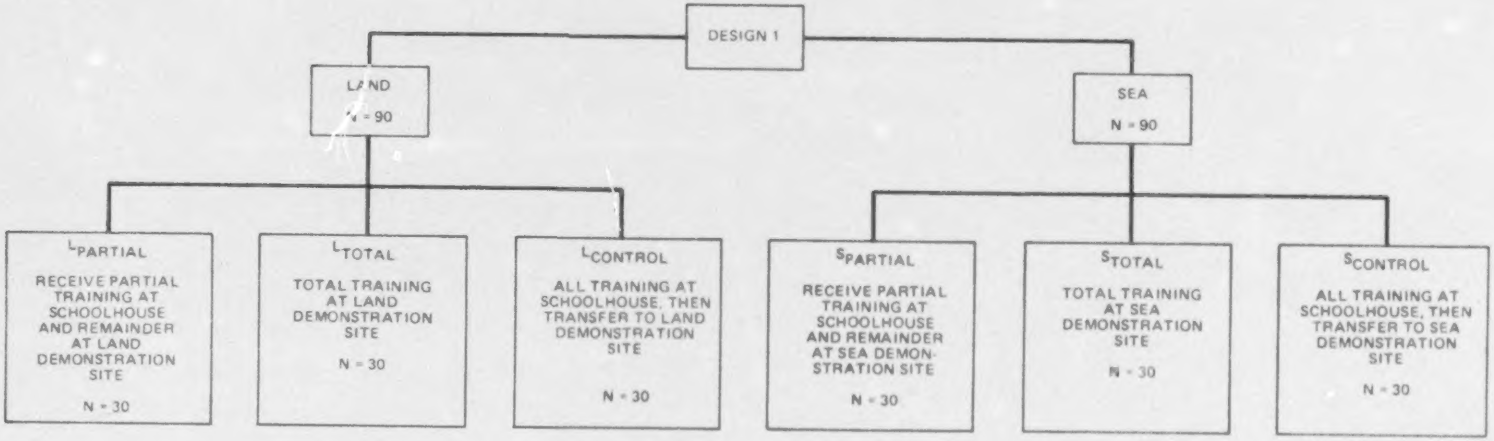
DESIGN 1
LAND
N = 90
SEA
N = 90
^{L}PARTIAL
RECEIVE PARTIAL TRAINING AT SCHOOLHOUSE AND REMAINDER AT LAND DEMONSTRATION SITE
N = 30
^{L}TOTAL
TOTAL TRAINING AT LAND DEMONSTRATION SITE
N = 30
^{L}CONTROL
ALL TRAINING AT SCHOOLHOUSE, THEN TRANSFER TO LAND DEMONSTRATION SITE
N = 30
^{S}PARTIAL
RECEIVE PARTIAL TRAINING AT SCHOOLHOUSE AND REMAINDER AT SEA DEMONSTRATION SITE
N = 30
^{S}TOTAL
TOTAL TRAINING AT SEA DEMONSTRATION SITE
N = 30
^{S}CONTROL
ALL TRAINING AT SCHOOLHOUSE, THEN TRANSFER TO SEA DEMONSTRATION SITE
N = 30

Figure VI-1. Pretest/Posttest Control Group Design—Ideal

land (L_c) and would complete their A-school training at the schoolhouse before being assigned to the demonstration site. Another of the groups in each body would be assigned for total training at the sea (S_t) and land (L_t) demonstration sites. The remaining group in each body would receive a portion of their training at the A-school and then be assigned to their respective sea (S_p) and land (L_p) demonstration sites, where they would receive the remainder of their training.

The requirements of this design make it highly unlikely as a choice for the demonstration. Specifically, problems are posed by:

- The requirement for 180 subjects
- The requirement for a land and a sea site for experimental groups
- The requirement that each remote site absorb 30 partially trained students, 30 untrained students, and 30 trained control group students at the same rate

The following discussion presents in an operational context the two design approaches which appear more likely as choices.

Plausible Design

Figure VI-2 illustrates a more plausible design with control and experimental groups for both possible remote environments. Here, the groups are eliminated that receive all of their training at the land and sea remote site. Nevertheless, in both cases there is a random stratified sample of at least 60 subjects, 30 for the control and 30 for the experimental group. All subjects start their training at the same A-school. The experimental groups, designated L_e and S_e, receive a portion of their training at the designated A-school and then are assigned to their respective operational land or sea site for the remainder of the CMI training, which would be interspersed with normal duties. The control groups, designated L_c and S_c, complete their CMI training at the A-school. They are then assigned to the same sites as their respective experimental groups. Comparisons could be made within and between groups which would

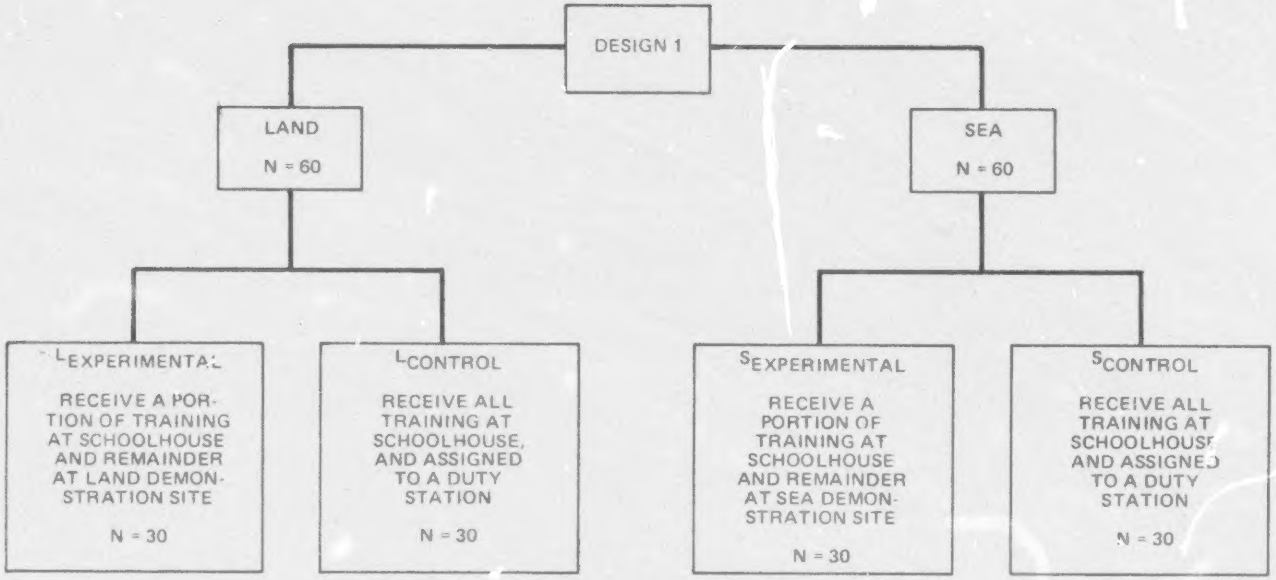
DESIGN 1
LAND
N = 60
SEA
N = 60
LEXPERIMENTAL
RECEIVE A PORTION OF TRAINING AT SCHOOLHOUSE AND REMAINDER AT LAND DEMONSTRATION SITE
N = 30
LCONTROL
RECEIVE ALL TRAINING AT SCHOOLHOUSE, AND ASSIGNED TO A DUTY STATION
N = 30
SEXPERIMENTAL
RECEIVE A PORTION OF TRAINING AT SCHOOLHOUSE AND REMAINDER AT SEA DEMONSTRATION SITE
N = 30
SCONTROL
RECEIVE ALL TRAINING AT SCHOOLHOUSE AND ASSIGNED TO A DUTY STATION
N = 30

Figure VI-2. Pretest/Posttest Control Group Design—Plausible

permit generalizing the results to both the sea and land operational environments. However, while being a more plausible design, this approach, like the first, presents a problem due to its requirement for each demonstration site to absorb 60 subjects in the same rate. In addition, 30 subjects would be only partially trained, which may not be acceptable, particularly on a ship.

c. Practical Design

A more practical design approach, which could be used to overcome the problem of a demonstration site absorbing 60 students, would be to follow the same procedures as noted above with the exception that only the experimental groups would be assigned to the demonstration sites. The members of the control groups would conclude their A-school training and be given normal assignments; related data gathering would conclude with completion of the course. However, if the number of untrained demonstration subjects still poses a problem, they could be distributed across a number of sites as depicted in Figure VI-3.

It is recognized that the addition of say five experimental sites to the design compounds the data collection procedures and problems, i.e., the chances of variance due to measurement error are five times greater. Also the chances of differential effects due to differences in experimental environments are five times greater with this design. Nevertheless, many procedural and statistical controls could be developed to account for design deficiencies.

2. Design 2

The previous design approaches assumed that the student personnel for the demonstration would be recruits selected from the various Class A-schools. Another possible approach would be to use existing personnel who are already at the demonstration site. This is the Design 2 concept.

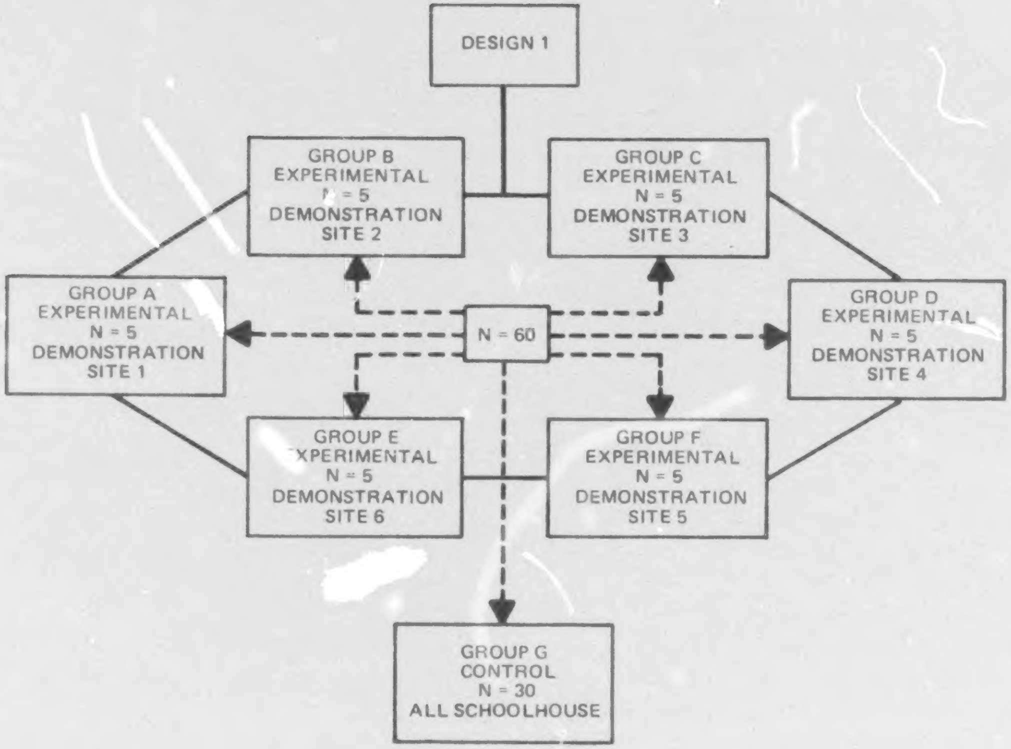
DESIGN 1
GROUP B
EXPERIMENTAL
N = 5
DEMONSTRATION
SITE 2
GROUP C
EXPERIMENTAL
N = 5
DEMONSTRATION
SITE 3
GROUP A
EXPERIMENTAL
N = 5
DEMONSTRATION
SITE 1
N = 60
GROUP D
EXPERIMENTAL
N = 5
DEMONSTRATION
SITE 4
GROUP E
EXPERIMENTAL
N = 5
DEMONSTRATION
SITE 6
GROUP F
EXPERIMENTAL
N = 5
DEMONSTRATION
SITE 5
GROUP G
CONTROL
N = 30
ALL SCHOOLHOUSE

Figure VI-3. Pretest/Posttest Control Group Design—Practical Multisite

Figure VI-4 portrays a Design 2 approach. This non-equivalent control group design is used when subjects cannot be randomly assigned to treatments. In this design one takes whichever groups are available for the demonstration (these groups constitute naturally assembled collectives) and randomly assigns each group a treatment condition. In this case it is extremely important to determine background characteristics for each group so that in the data analysis stage differences which are attributable to these characteristics, rather than to the treatment, can be determined.

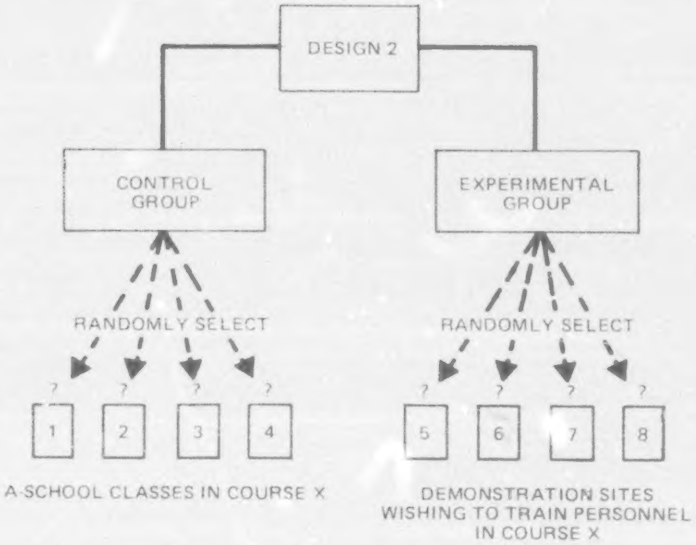
DESIGN 2
CONTROL GROUP
EXPERIMENTAL GROUP
RANDOMLY SELECT
RANDOMLY SELECT
?
?
?
?
?
?
?
?
1
2
3
4
5
6
7
8
A-SCHOOL CLASSES IN COURSE X
DEMONSTRATION SITES WISHING TO TRAIN PERSONNEL IN COURSE X

Figure VI-4. Nonequivalent Control Group(s) Design

In this situation there are two possible realistic options. The first would be where operational sites wish to participate in the demonstration using A-school or CMI "Operational Readiness" courses to provide training to existing personnel. Here, as delineated in Figure VI-4, the treatment or CMI course would be randomly assigned to one or more of the intact site groups, and the control group would be randomly selected from classes of personnel passing through the same type training at a schoolhouse. Using this design approach eliminates the requirements for obtaining BUPERS approval for the assignment or movement of personnel and demonstration site approval for the absorption of a partially trained experimental group. Another potential advantage is that it may be possible to obtain a large sample size, one that exceeds the 30 minimum. Of course, as discussed above, considerable information on the background of individuals and the learning environment is required for this design approach in order to account for results not attributable to the demonstration treatment.

A point that needs to be made here is that if a demonstration site, a ship in this case, were to decide that it wants an "Operational Readiness" course, it may be possible to work with the NPRDC CII (Computer Integrated Instruction) demonstration effort. Assuming similar data is being collected on the CII project, not only could one explore the merits of a decentralized computer and centralized computer in providing instructional support, but comparisons possibly could be made in such areas as resource requirements, cost-effectiveness, management organization requirements and types of services best provided. The design is depicted in Figure VI-5.

In its present status the NPRDC project is using the U.S.S. Gridley as an experimental site and the U.S.S. Halsey as a control site. Procedures for this project consist of pretests, CII or traditional instruction, posttests, and retention tests. As envisaged, to make comparisons would require an additional ship similar to those being used and would also require placing the NPRDC GDC Course on CMI. The CMI

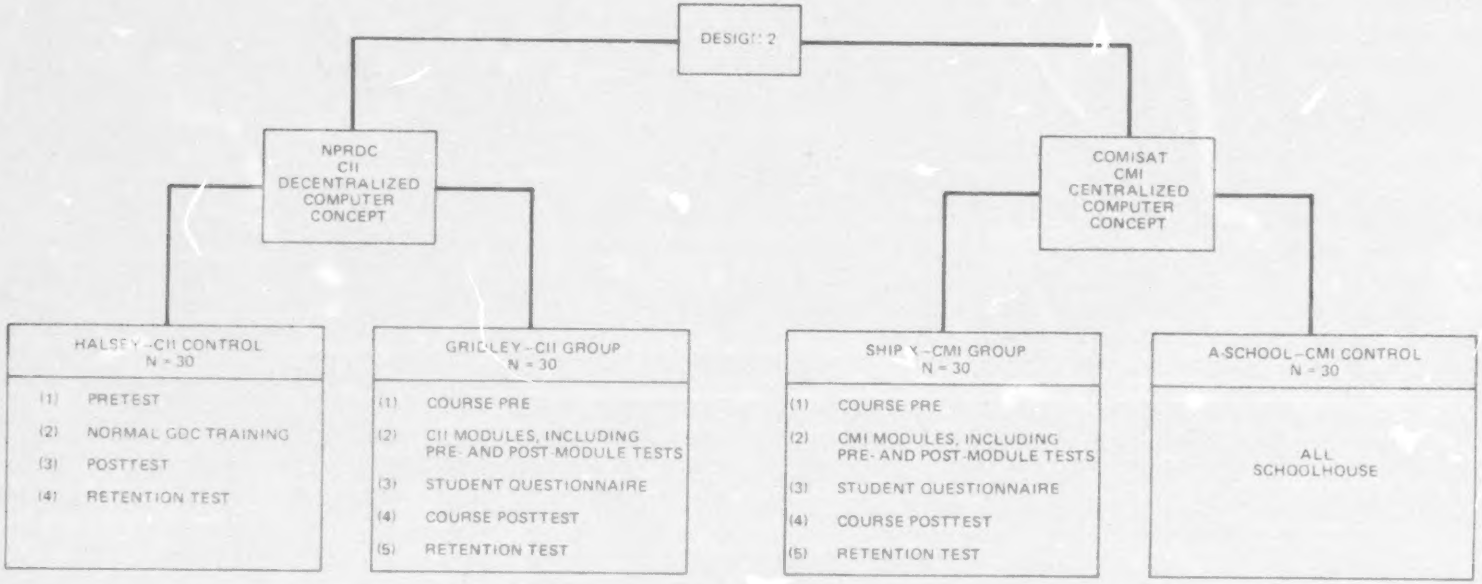
DESIGN 2
NPRDC CII DECENTRALIZED COMPUTER CONCEPT
COMISAT CMI CENTRALIZED COMPUTER CONCEPT
HALSEY–CII CONTROL N = 30
(1) PRETEST
(2) NORMAL GDC TRAINING
(3) POSTTEST
(4) RETENTION TEST
GRIDLEY–CII GROUP N = 30
(1) COURSE PRE
(2) CII MODULES, INCLUDING PRE- AND POST-MODULE TESTS
(3) STUDENT QUESTIONNAIRE
(4) COURSE POSTTEST
(5) RETENTION TEST
SHIP X–CMI GROUP N = 30
(1) COURSE PRE
(2) CMI MODULES, INCLUDING PRE- AND POST-MODULE TESTS
(3) STUDENT QUESTIONNAIRE
(4) COURSE POSTTEST
(5) RETENTION TEST
A-SCHOOL–CMI CONTROL N = 30
ALL SCHOOLHOUSE

Figure VI-5. CII/CMI Combination Design

version of the course could be used at an existing HT school to serve as a control, and aboard ship with existing personnel, who would serve as the experimental group. The comparison could yield invaluable information for the design of future computer-based support systems for remote site training.

D. Impact of Demonstration Site

Except for the CII discussion, the demonstration site concept has been treated in a rather neutral manner. As noted at the outset, the best design would incorporate both land and sea sites. However, if only one type of site is available, the basic demonstration purpose would still be achievable. For a worst case environment, it is assumed that a ship would serve as the best demonstration site because of its operational pressures, limited physical area, and so on. Nevertheless, remote land sites as well as ships have training requirements which must be met and thus would serve as excellent demonstration sites. The designs that have been discussed are applicable to land or sea remote sites.

E. Design Procedures and Potential Problems

This section treats the specific methodologies for conducting the demonstration. Specifically, it addresses a number of areas of concern related to general research procedure, including testing and training procedures, data collection and analysis procedures, data accuracy factors, and other influencing factors.

1. Testing and Training Procedures

Among the many types of data to be collected are course test data and attitudinal data. Collecting these data would require administering learning-related tests including a pretest; CMI module tests; a posttest; and attitudinal tests, which should be given at the beginning and end of the course. Whether new or existing personnel are used would impact the testing procedures. If existing personnel are used, tracking students from pretest to posttest periods would be less complicated, since personnel would not be transferring from one site to another. Control subjects would take all of their training and tests at a schoolhouse while experimental subjects would take their training and testing at the demonstration site. Although the experimental subjects would take the same course tests as the control subjects, the total training period would be expanded and the procedures changed to account for working hours and site duties.

Using the Radioman course as an example, the following scenario illustrates that if new personnel were used the testing procedures would be more complicated. Pretests for control and experimental groups would be administered at the beginning of the first training day, with attitudinal testing requiring two or three hours. At the completion of the Basic Shipboard Systems Laboratory portion of the course, when the experimental subjects are ready to transfer to the demonstration site, a second test of approximately the same length as the first would be administered to collect benchmark data. Then, because leave and other factors are likely to result in a time lag of up to two weeks before the experimental subjects actually arrive at the demonstration site, a third test would be required upon their arrival. Final testing, at the end of the Prac Deck, would include final course exams and attitude questionnaires.

In considering a possible procedural walk-through of the testing and CMI training at a demonstration site, it is assumed that approximately two hours per day would be "dedicated time" for training, with the exact time period depending on a number of factors.

The student, along with his learning supervisor, would have to determine a schedule which could allow him two hours of "dedicated time" for CMI training. From an educational point of view, the best time for a student to learn would be sometime before a work period or after he has had an opportunity to rest. However, given the operational scheduling of a ship, this may not be feasible.

Nevertheless, after the schedules have been established, the student would first check in with the learning supervisor to receive his module assignment. Then, once he has the appropriate instructional materials, he would return to his bunk or other designated area to begin studying for the module. After the student has completed his study and preparation for the module test, he would return to the designated testing site to receive the mark sense answer sheet and test booklet. After completing the module test, his answer sheet would be collected for entry into the OpScan unit. Before the beginning of the lesson for the next day, the student would receive feedback on the previous module and, provided he has passed, could go on to the next module. Should he not pass the module, the CMI system provides the student with remedial loops which he would follow until he has successfully completed a given module.[1]

In view of the operational complexities of a large demonstration site(s) as well as organizational problems connected with having approximately 1,000 or more personnel at the experimental site, it would be necessary for CMI students to work out their schedules very carefully with the learning supervisor. The fact that 30 or more students would be involved in the experimental group(s) would require that opportunities be made available throughout the day for two-hour learning blocks. In addition, the learning supervisor would have to be available across the time spectrum. This may mean that more than one supervisor would be required.

2. Data Collection and Analysis

The data from the module test would be fed directly into the OpScan device and transmitted via the site communications system to the communications center at the land base (technical details of this operation are presented in Chapter III). Test feedback would be transmitted back to the site and the student would then move to the next module in the training program.

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[1] All of this assumes a five-day work week, which is the case with the computer center in Memphis. Time differences between zones at different demonstration sites will mean that careful scheduling for training time, course testing, and communication will have to be maintained during the demonstration.

Attitude data would be received by testing personnel, packaged, and sent to research personnel at the contractor's headquarters for analysis and evaluation. It is worth emphasizing here that the ideal situation would call for having extra research personnel at the demonstration site(s) during the testing periods to insure that no data collection difficulties arise. In a complex field environment, it is important to exercise as many procedural controls as possible to insure that all necessary data are collected.

3. Data Accuracy

Rigid controls would need to be exercised during module testing and attitude surveying times to make certain that data collected is valid or that data has actually been collected. The ideal solution to both of these problems would be to have trained research personnel at the demonstration site to oversee the testing and survey administration. Should this not prove feasible, appropriate instructional/training personnel should be trained to understand the importance of careful control during all phases of the demonstration. It is also possible to control for extraneous variables during the administration of attitude surveys by tape-recording all instructions. Tape-recording survey instructions not only makes the administration uniform and more efficient across all conditions, but also allows the surveyor an opportunity to devote full attention to the proctoring of students as they complete tests and survey questionnaires.

4. Other Influencing Factors

a. Delayed Feedback

Feedback time for module testing at sites could range between 4 hours and as much as 24 or more hours. The practical problem is that a student may not be allowed to advance to the next module in the training program without some information regarding his status in the present module test. From an educational point of view it would hardly seem practical to allow a student to proceed without knowing whether he has passed the previous module. Without such feedback the student could be enhancing errors detrimental to the next module in the course sequence. In addition, should the student be allowed to advance to the next module without feedback or remedial loops on the previous modules, the content of the next module could cue the student on materials from the first module and confound the learning process for the overall training program. Consequently, a means must be found for dealing with the potential problems of delayed feedback.

b. Instructor Personnel

The most difficult control problem has to do with the instructor personnel. The learning supervisor could become an extraneous variable requiring careful attention during design and demonstration phases. The "demand characteristic" or "experimenter bias" phenomenon was first systematically studied by Rosenthal (1964 and 1966). His conclusion was that an experimenter's knowledge of the experimental hypothesis could have profound and difficult-to-determine effects on the outcome of the research. Aside from using some kind of automated data administrator, it can only be assumed that the number of data collections acting as confounding variables would be controlled by being "randomized out." The only other method of controlling this factor is for the learning supervisor not to be informed of the specific research hypotheses being investigated. Therefore, demonstration personnel should be informed and trained for the tasks they will be required to perform, but they should not be informed of the specific research hypotheses.

F. Summary

A summary of demonstration project objectives, conditions, design possibilities, research dimensions, sampling and measurement procedures is depicted in Table VI-1.

Table VI-1. COMISAT Design Option Summary

Project Objectives	Necessary Conditions	Research Design Possibilities	Possible Research Dimensions	Population Size/Sampling/Statistics	Data Collection/ Measurement Procedures
• Determine whether CMI delivered to remote sites produces the same learning effectiveness as CMI does in the learning center environment. • Determine whether CMI delivered to remote sites is as economical as CMI in the learning center environment. • Determine whether the attitudes of students, trainers, and key remote site personnel are supportive of CMI delivered to remote sites. • Determine the personnel requirements. • Determine the personnel training requirements. • Determine the organization and management structure required. • Determine the remote site space requirements and operational procedures for effective use of a CMI training system. • Determine the equipment maintenance, spare parts, and logistics requirements to support a remote site CMI training system.	• Designated shipboard or remote land site setting for demonstration. • Designated control sites for demonstration. • Selection of a CMI A level course or modules for demonstration from existing courseware on CMI (Radioman, Machinist Mate, Boiler Technician, BE&E, etc.) or an "Operational Readiness" course required by all Navy personnel. • Ideally, CMI courseware selected should relate to OJT opportunities aboard ship. • Access to the Navy communications system for demonstration period. • Adequate sample population of Navy recruits, enlistees, or existing Navy personnel for an evaluation effort (no less than 30 Ss per each control/experimental condition specified).	Pretest/Posttest Control Group(s) Design • Two or more equivalent groups of Ss, one designated experimental, the others control (e.g., one completing CMI on land then going to ship, the other continuing CMI on ship).[1] • Application of pre- and posttests comparing specific activities of the experimental group with the control groups, before and after respective CMI experiences. • Equivalence is to be achieved by randomization and stratification of groups on a set of predetermined distinguishing characteristics (IQ, age, years of schooling, performance on battery of Navy vocational aptitude measures, quota % of representative recruits, etc.). Assurance of equivalence is greater for large number of random assignments than for small number. • Design calls for simultaneous and maximum similarity of experimental and control treatments and for counterbalancing of treatment occasions (the data collectors, time of day, day of week, length of session, etc.). • Great concern should be given to repeatability of design conditions to insure that findings are generalizable. With indicated sample size, there remains the possibility that effects validly demonstrated hold only for that unique population from which the experimental and control groups were jointly selected. Non-Equivalent Control Group(s) Design • Should random assignments or pre-experimental sampling equivalence in groups selected not prove possible, the nonequivalent control group design is recommended. Ss are less likely to be reactive to experimental research setting. In this case, whatever groups are designated for the study are viewed as constituting naturally assembled collectives, such as intact classrooms, that are similar as availability permits. In this instance, the assignment of CMI to one group or the other is assumed to be the random assignment of Ss. Thus, unlike the Pretest Posttest Control Group(s) Design above, in which experimental Ss are assigned randomly from a common population to the experimental control groups (and have a greater likelihood of creating an "I'm a guinea pig" attitude), the treatment is assigned randomly to nonequivalent groups. This reduces greatly the equivocality of interpretation of findings. The more similar the experimental and the control groups are found to be in their recruitment, and the more this similarity is confirmed by the scores of pretesting on relevant research variables, the more effective this control design becomes. • Care should be given to pretest measures to avoid sensitizing the research population. Where highly unusual test procedures are used, e.g., testing procedures involving deception, stress, perceptual or cognitive restructuring, surprise, it might be best to avoid pretesting the experimental group and to set up an additional equivalent group that serves as a pretest baseline sample.	Dependent Variables • Time taken to reach CMI criteria[2] Predicted, Actual and Difference • Student/Instructor Attitudes Toward CMI and Demonstration (Pre- and Posttests) (Affection) • Student/Instructor Attitudes Toward Each Other • Student/Instructor Morale • Student Self Concept Measure • Student OJT Performance (Behavior Quality and Quantity): Control Group 2 and Experimental Group • General Aptitudes in Subject Field of Designated CMI Course (Pretests and Posttests) (Cognition) • Student Motivation to Undertake Training (Pre- and Posttests) (Affective) Demographic and Intervening Variables • IQ, Age, Years of Schooling, Performance on Battery of Navy Vocational Aptitude Measures • Rule of Feedback to CMI Lessons • Attitudes of Training and Site Support Personnel (Instructors, Ship Crew, etc.) • Reading Skill • Numerical Ability Other Data • Administrative History of Project – logistics – organization – management – material – personnel requirements – space and facilities requirements – costs – hardware software configuration • Cost Effectiveness Cost Benefit Analysis	Situation 1 (Randomly Stratified Sample) • Sample population consists of 60 Ss picked from same class with one half (N=30) being assigned randomly to Experimental Treatment and the remaining one half to the Control Treatment. • Were this sample to be increased by an extra 30 Ss, a second control group could be established—those Ss who complete all of their CMI on land and then go directly to their workday activities aboard ship. Compare their OJT performance with that of the experimental group aboard ship. • An additional 30 Ss would also allow for an experimental group who take all of their training at an experimental site rather than taking part at the base school and part at the experimental site. • Should additional Ss not be available, the experimental and control groups would all begin their CMI on land together and at some designated point in time, one half would go to ship to continue CMI; the other half continues CMI at land site. If control group 2 were added, this class would have had to have completed all their CMI on land at that point in time when the experimental group goes to the shipboard setting—they would accompany this group. Situation 2 (Non Equivalent Groups, Random Treatment) • Sample population consists of two or more separate classrooms of 30 Ss in each, assumed to be as similar as availability permits. This design could also use new or existing personnel. • Design would call for randomly picking one class or the other and assigning it to the Experimental Shipboard/Remote Land Setting to continue CMI. Second class as a group would continue CMI at land site. • Similar to Situation 1, a second control classroom could be set up. Thus, we would have a total of three classrooms with 30 Ss in each. • Later use relevant background information in analyzing results—correlation/regression analyses or covariance analysis to analyze differences. • The most widely used acceptable parametric test of significance for these designs is to compute for each group pretest posttest scores on the relevant research variable and then to compute a "t" ratio between gain scores. Because of a reduced error term and the assumed "nonequivalence" of groups, pretest scores and analysis of covariance are to be preferred to simple gain score comparisons. Should any of the parametric assumptions for covariance analysis be compromised, then appropriate nonparametric statistics would be used for the analysis.	• CMI Test Item Analysis Courseware Modules • CMI Printout and History on Students • Student Background Information Files • Attitude Questionnaires • Motivation Scales • Morale Scales • Student Self Ratings • Supervisor Rating of Students • General Courseware Aptitudes of Students • Attitudes of Instructors/CMI Support Personnel Toward Experience

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[1] The ideal would call for three treatment groups plus an additional group who receive all of their training at the experimental site.

[2] Absolute criteria varies from about 80% to 100%. If criteria is less than 100%, then an additional variable may be [illegible] score on test.

Chapter VII
ECONOMIC ANALYSIS MODEL

A. Introduction

This Chapter describes the approach to be followed in performing the economic analysis of a proposed operational, self-paced, Computer Managed Instruction (CMI) via satellite system and its alternatives. The objective of this analysis is to determine whether satellite-delivered CMI to shipboard or remote land sites is as economical as CMI in the learning center environment. Here, the term economic analysis is synonymous with Systems Analysis, Cost-Benefit Analysis, or Systems Evaluation since the output of the analysis will be structured information which will aid decision makers in evaluating the various training system options available to them on the basis of meeting training objectives and considering cost, risks and uncertainties. The specific objective of the analysis is to compare a proposed operational system designed to provide CMI instruction at remote sites which are linked to the CMI computer at Memphis, Tennessee, by a Navy communications system against other Navy training systems which can provide such CMI instruction, determining the preferred system for different future time periods and student load conditions as an input to the development of a Master Implementation Plan.

The economic analysis is based on the following assumptions:

- The only training system alternatives we shall evaluate are those utilizing CMI. Hence, training systems using Instructor Managed Instruction (IMI) or traditional classroom instruction will not be considered.
- The performance and cost data used in the evaluation will be based on the current operational CONUS-based CMI system, the

COMISAT demonstration, and the U.S.S. Gridley minicomputer CMI demonstrations, as extrapolated to fully operational systems.

The content of this chapter includes:

- The approach to be followed
- The information and data to be collected in implementing the analysis

B. Analytical Approach

The economic analysis will be performed in the following fashion:

1. Identify Alternative System Concepts

The first step is to identify the alternative ways of delivering Navy CMI training, for which performance and cost data will be available at the time of the Evaluation Phase. As shown in Figure VII-1, four distinct CMI training system concepts have been identified and will be evaluated in this analysis. These are:

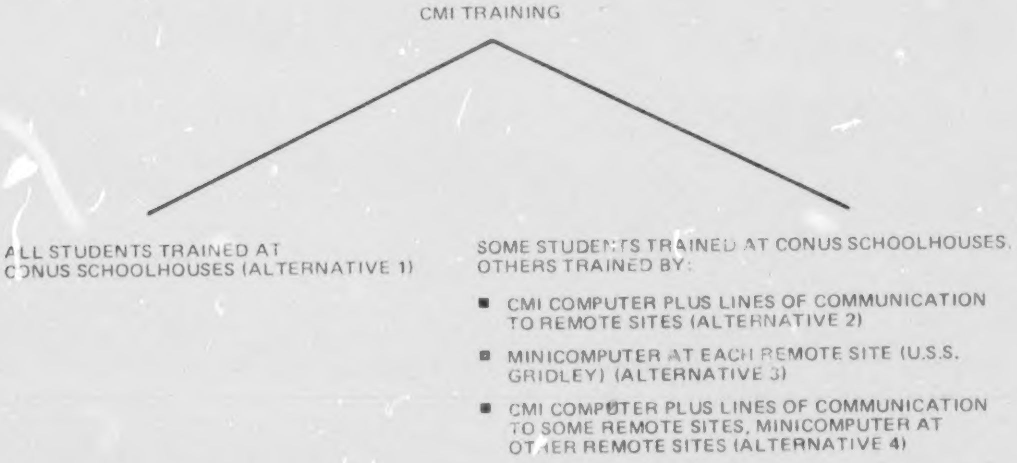
CMI TRAINING
ALL STUDENTS TRAINED AT CONUS SCHOOLHOUSES (ALTERNATIVE 1)
SOME STUDENTS TRAINED AT CONUS SCHOOLHOUSES, OTHERS TRAINED BY:
■ CMI COMPUTER PLUS LINES OF COMMUNICATION TO REMOTE SITES (ALTERNATIVE 2)
■ MINICOMPUTER AT EACH REMOTE SITE (U.S.S. GRIDLEY) (ALTERNATIVE 3)
■ CMI COMPUTER PLUS LINES OF COMMUNICATION TO SOME REMOTE SITES, MINICOMPUTER AT OTHER REMOTE SITES (ALTERNATIVE 4)

Figure VII-1. Alternative CMI Training Systems Being Considered

- Alternative 1: All students trained at CONUS schoolhouses. This is the current system using the CMI computer at Memphis with land lines to various Navy CONUS schoolhouses. Each of the remaining alternatives consists of some students being trained at the CONUS schoolhouses and the rest being trained at remote sites in the following three ways:

- Alternative 2: Using the CMI computer at Memphis connected by suitable means of communication to the remote sites (the current COMISAT project).

- Alternative 3: Using a minicomputer at each remote site to perform the same functions as the CMI computer, thus not requiring either the Memphis computer or the same lines of communication as Alternative 2. This system would be designed after the Shipboard Command Management and Readiness System as demonstrated on the U.S.S. Gridley. It should be noted that this system performs a number of administrative functions in addition to the training function. Hence, we shall have to pay special attention to relating total costs to the various functions this system provides.

- Alternative 4: A mix of some students trained at those sites which will have the minicomputer anyway because of the other, non-training applications it provides (Alternative 3) with the remaining students using the CMI computer (Alternative 2). While this alternative is really a mix of Alternatives 2 and 3, it may have merit for consideration if a minicomputer is to be procured for some sites anyway, since the incremental cost for the training system may be small.

A fifth alternative was also considered, using the same approach as Alternative 2 except attempting to reduce the satellite use time required to a minimum. Two implementation possibilities exist within this alternative. The first is to redesign the narrative replies so that they convey the same basic information but require less characters than currently estimated (600 to 800 characters). The second approach would be to reprogram the Memphis CMI computer to send student reply information to the remote site in coded form rather than narrative text. The information would then be fed into a microprocessor at the remote site which would translate the reply into the normal narrative text format of the current CMI system and print it on a separate terminal. It is assumed that the first possibility would be included as part of Alternative 2 as new CMI courses are designed. We could evaluate the second possibility (the use of a microprocessor as a reply translator) if requested to do so.

Two other alternatives are also possible at remote sites:

- Instructor Managed Instruction (IMI) in which the instructor (or chemically treated test paper) is used to grade the tests and remedial instruction loops are available as part of the Audio-Visual training package. This option may be superior if only a few students on the ship are participating in training.
- A minicomputer devoted only to CMI training.

Neither of these alternatives will be considered in the evaluation since performance and cost data for the alternatives will not be available.

2. Define the Training System Objectives

The next step in the analysis is to more precisely define the operational objectives which all system alternatives will be designed to meet. In the case of the COMISAT program we can define these objectives in the following way. At some future time when an operational CMI system is required:

- There will exist a set of CMI courses available for instruction (i.e., the courseware has been developed, programmed, coded, and validated in the CMI format).
- These courses will be designed to fill the following training needs:
  - -- A-school courses[1] given to students immediately upon completion of their recruit training.
  - -- A-school courses given to selected students already assigned to a ship who have never had such training but could profit from it. Some of these students would normally be assigned to CONUS A-school as "fleet returnables."

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[1] A-school is the Navy designation of "initial skill training," referred to as Advanced Individual Training and Technical Training by the Army and Air Force, respectively.

Because of manning limitations, the remainder of these students will not have the opportunity of attending CONUS A-schools.

- Other courses of a more general nature, such as General Damage Control, normally given at the ship rather than at CONUS schoolhouses.
- CMI courses which would provide the same educational content as correspondence courses now given to students at sites.

- The requirement of the CMI training system can be defined as providing a given number of graduates from each of these courses for each operational year of the CMI training system.

3. Identify Differences Among Alternative Systems

When these various types of courses are delivered to the available students using the four different training system alternatives defined previously, certain differences in performance and total cost of delivering the training are expected to exist. An identification of these differences and an explanation of how they can be measured in the analysis are given below and illustrated in Figure VII-2.

a. Factor 1: Student Training Time in CMI Course

The man-hours required for students to satisfactorily complete a course may differ among training systems. These times will be converted into equivalent student billet costs by determining over how many weeks the training extended and what proportion of this time was spent in training, as compared with other duties.

Student Billet Costs contribute to the hierarchy of costs as shown in Figure VII-2.

b. Factor 2: Standard Work Week

The standard work week while stationed at sea is greater than while stationed at a CONUS schoolhouse. Thus, student billet costs per hour are less at sea than at CONUS.

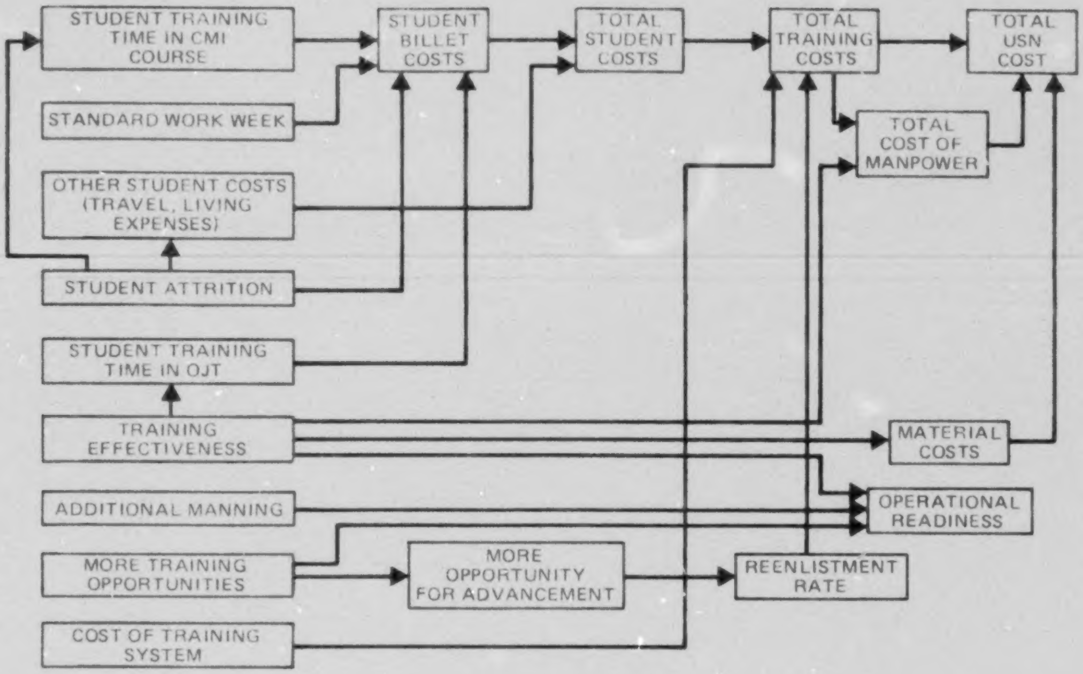
STUDENT TRAINING TIME IN CMI COURSE
STUDENT BILLET COSTS
TOTAL STUDENT COSTS
TOTAL TRAINING COSTS
TOTAL USN COST
STANDARD WORK WEEK
TOTAL COST OF MANPOWER
OTHER STUDENT COSTS (TRAVEL, LIVING EXPENSES)
STUDENT ATTRITION
STUDENT TRAINING TIME IN OJT
TRAINING EFFECTIVENESS
MATERIAL COSTS
ADDITIONAL MANNING
OPERATIONAL READINESS
MORE TRAINING OPPORTUNITIES
MORE OPPORTUNITY FOR ADVANCEMENT
REENLISTMENT RATE
COST OF TRAINING SYSTEM

Figure VII-2 Identified Differences in Performance and Costs Among Training System Alternatives

c. Factor 3: Other Student Costs

Other student costs such as transportation and living expenses while traveling, which also occur while the student is in training, may also differ among systems. These will add to the total student costs.

d. Factor 4: Student Attrition

Certain students may not graduate from the course. The time spent by attrited students while in training and all other student resources they require during this time may differ among systems. All of these resources will be converted into equivalent student costs and added to the costs of the graduating students. It is important that this measurement only include those students who attrite because of academic reasons. Current attrition measurements include other reasons such as health and misconduct which are not relevant to this analysis.

e. Factor 5: Student Time in OJT

Some of the alternatives may provide synergistic effects on other concurrent functions. For example, conducting CMI training concurrently with OJT (on-the-job training)[1] and work assignments may result in the OJT being completed more rapidly, particularly if the CMI course was designed around the specific set of equipment in place at the job site, rather than around a general set of equipment at the CONUS schoolhouse. Such time reduction would also reduce the equivalent student billet costs attributed to OJT in the same way as previously described for a CMI course.

f. Factor 6: Training System Costs

The cost of developing, installing, operating, maintaining, and supporting each training system alternative may differ. These costs (not including the student costs previously described) will be defined as Training System Costs. Such costs are obviously a function of the amount of student training provided.

g. Factor 7: Additional Manning at Remote Sites

At the same time that training occurs on the ship, the student is also able to spend part of his time doing productive work under direction of his supervisor. This difference among system alternatives will be measured using standard cost accounting techniques. The proportion of the standard work week used for the CMI course and OJT will be charged against Productive Time, except for one adjustment factor. We shall also determine the "Average Trainee Unproductive Time," defined as that time when there was not productive work that could be assigned to the student because of his lack of training. Unproductive time will also include taking longer than a "standard time" to complete a task. The productive man-hours provided by a student will be converted to the equivalent of additional men "on board."

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[1] OJT in the context used here applies to rate-unique training as differentiated from general military training (GMT).

h. Factor 8: Training Effectiveness

One training system alternative may result in more effective training than another. This difference might be expressed in a difference in test scores. However, to analyze the value of such differences, research would have to be performed relating test scores and later production on the job in terms of being able to do productive work faster or better or complete OJT faster. These benefits could result in less manpower required as well as less wasted materials. It may not be possible to quantify this difference among systems during the demonstration phase.

i. Factor 9: More Training Opportunities

Providing more training opportunities to those who would normally not be able to take such courses would aid in two ways. First, it would provide the individual further opportunity for advancement, thus increasing the reenlistment rate and reducing replacement training costs. In addition, it would increase the operational readiness of the ship. It may not be possible to quantify the difference among systems during the demonstration phase.

4. Compare and Analyze Differences

An initial statement of the economic analysis problem might be:

> "Compare the total system lifetime costs of obtaining the required CMI course graduates using the CMI satellite system with all other ways of doing the same job. In addition, determine the economic value of the additional benefits described and the additional costs which any of these CMI training system alternatives provide that other system alternatives do not provide."

As indicated previously, it is assumed that all of the information required to make such calculations (as described in this report) will be obtained as performance and cost data based on an extrapolation of actual CMI system operations of:

- The current CONUS CMI system.
- The satellite CMI system demonstration.
- The minicomputer system (U.S.S. Gridley).

We shall perform the analysis by:

- Designing each of these system alternatives so that each will produce the same required number of course graduates.
- Analyzing the nine differences identified among systems and calculating for each system design alternative:
  - -- The total student costs attributed to training (including student salaries, travel, benefits and living expenses) to produce the same number of student graduates desired, taking into account the anticipated attrition of each system alternative.
  - -- All training system costs.
  - -- All other benefits obtained (as described previously) which differentiate one system alternative from another, resulting in either reduced costs, or providing non-monetary benefits.

C. Constructing the Scenarios

Figure VII-3 illustrates the time sequence of activities involved in training, travel and work under three hypothesized scenarios. The variable T represents the time in weeks for an activity, and M represents the manhours devoted to it.

The first scenario represents the current CMI training at CONUS schoolhouses, with two travel periods and expenses (to A-school and to the ship). The second scenario would be for those courses in which the student could travel directly to the ship and then begin the course, requiring only one travel period. The third scenario, requiring two travel expenses, is for those courses which must be begun at the CONUS schoolhouse, followed by

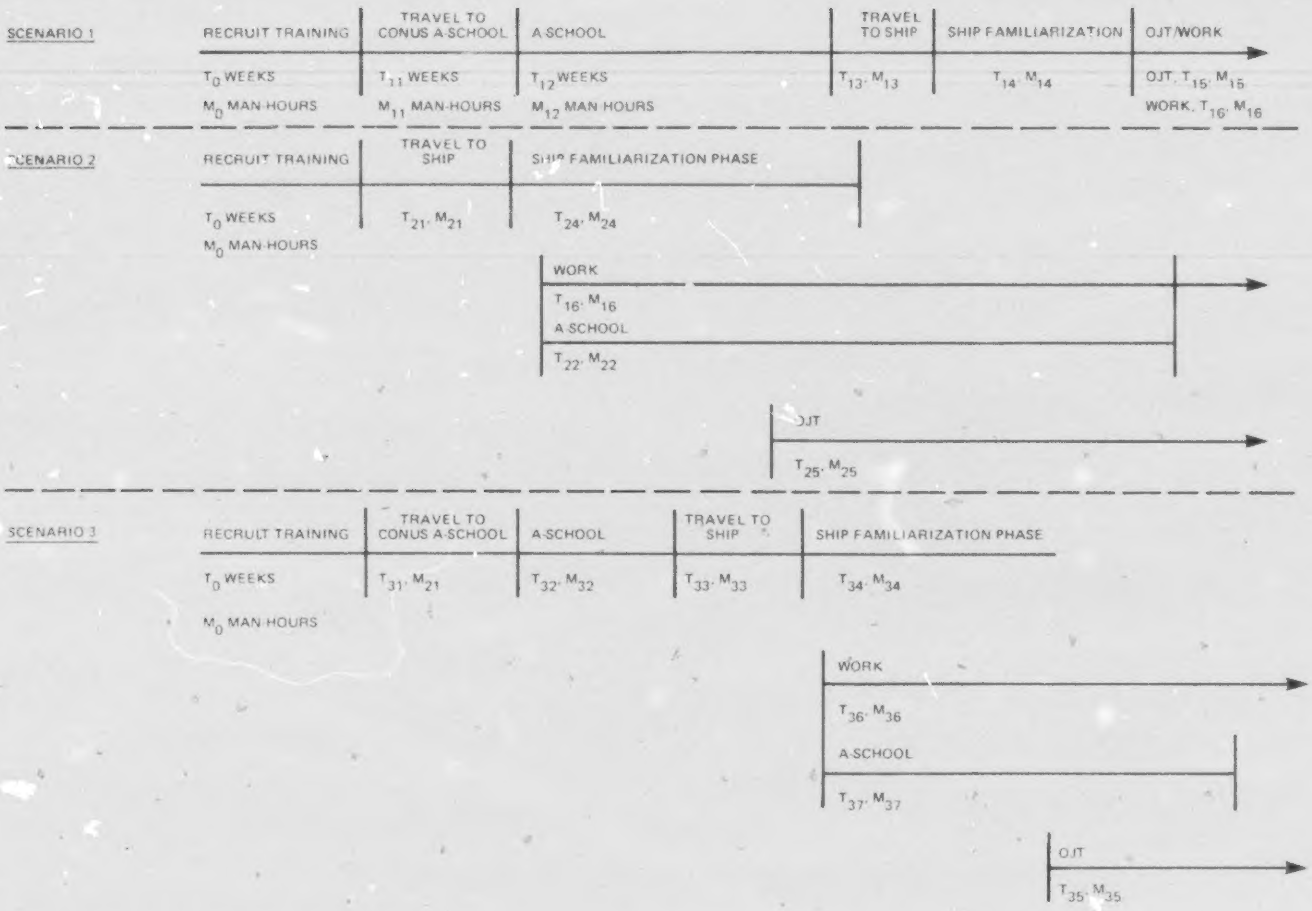
SCENARIO 1
RECRUIT TRAINING
TRAVEL TO CONUS A-SCHOOL
A-SCHOOL
TRAVEL TO SHIP
SHIP FAMILIARIZATION
OJT/WORK
T_0 WEEKS
M_0 MAN-HOURS
T_{11} WEEKS
M_{11} MAN-HOURS
T_{12} WEEKS
M_{12} MAN-HOURS
T_{13}, M_{13}
T_{14}, M_{14}
OJT, T_{15}, M_{15}
WORK, T_{16}, M_{16}
SCENARIO 2
RECRUIT TRAINING
TRAVEL TO SHIP
SHIP FAMILIARIZATION PHASE
T_0 WEEKS
M_0 MAN-HOURS
T_{21}, M_{21}
T_{24}, M_{24}
WORK
T_{16}, M_{16}
A-SCHOOL
T_{22}, M_{22}
OJT
T_{25}, M_{25}
SCENARIO 3
RECRUIT TRAINING
TRAVEL TO CONUS A-SCHOOL
A-SCHOOL
TRAVEL TO SHIP
SHIP FAMILIARIZATION PHASE
T_0 WEEKS
M_0 MAN-HOURS
T_{31}, M_{21}
T_{32}, M_{32}
T_{33}, M_{33}
T_{34}, M_{34}
WORK
T_{36}, M_{36}
A-SCHOOL
T_{37}, M_{37}
OJT
T_{35}, M_{35}

Figure VII-3. Training and Work Activities

transfer to the ship where the course is completed, along with the other duties depicted in the second scenario. In addition, total student costs are affected by:

- How many man-hours (of duty time as opposed to free time) were spent by the successful graduate in completing the course?
- What is the standard work time per week expected of the student?
- What attrition rate occurs for the course?
- How many student man-hours were spent before attrition?

By comparing the man-hours required to complete the various training and other activities for the CONUS CMI system with that required for the remote site systems, we can determine time (and cost) differences between systems.

- Assume that there is a requirement for A graduates of a given CMI course for a particular operational year.
- However, because of attrition, assume that B additional students must enter the course during this year.

D. Calculating Student Costs

Student costs are defined as all expenditures spent directly on the student because he has attended the course and include:

- Billet Costs (salary, benefits and living expenses per week)
- Travel Costs

These costs are for both graduates as well as those who attrite from the course.

1. Recruit Training

Let T_0 be the average time (in weeks) for recruit training. While this time may be the same for all students who enter A-school, some students who fail to graduate A-school are discharged and hence have no value to the military; therefore, the total cost of recruit training for these discharged students must also be considered as a part of the training costs. $M_0 = T_0$ since this is a full-time activity. Assume that D of the B students who attrite are discharged. Thus, the recruit training cost attributable to later A-school attrition (CRT) is:

$$CRT = D(T_0 \; BC + CUR)$$

where BC = Weekly student cost (salary, benefits and living expenses)

CUR = Unit cost of recruiting one enlistee

2. Student Billet Cost During Travel

Let T_{11} be the average travel time from Recruit Training Center to CONUS A-school,[1] T_{13} be the average travel time from A-school to the ship, and T_{21} be the average travel time from the Recruit Training Center to the ship for system alternatives 1 and 2. All times are in weeks.

The total billet costs during travel (BCT) for the CONUS alternative 1 are:

$$BCT_1 = [(A_1 + B_1)T_{11} + (A_1)(T_{13})] \; BC$$

and for alternative 2 are:[2]

$$BCT_2 = [(A_2)(T_{21})] \; BC$$

---

[1] Leave time will not be included in these calculations since it accrues to the student and will be used eventually by him.

[2] This assumes that all attrited students from system 2 (B_2) remain on the ship and are productive in some other rating whereas the travel costs for the attrited students from system 1 (B_1) are a complete loss.

where A and B are the number of course graduates and non-graduates, respectively, of system alternatives 1 and 2, and the difference in travel times is reflected as shown.

Obviously, the third scenario requires the same travel time as the first.

3. Transportation Costs

The remaining cost of transportation (CT) depends on the distances involved:

$$CT_1 = (A_1 + B_1)TC_{11} + A_1 \; TC_{13}$$

$$CT_2 = A_2 \; TC_{21}$$

where TC_{11}, TC_{13}, and TC_{21} are the average transportation costs (including per diem, living expenses, while en route) from the recruit training center to CONUS A-school, A-school to ship, and recruit training center to ship, respectively.

4. Student Cost During Training

Figure VII-4 illustrates how an individual would spend his productive time under scenarios one and three.[1]

The proportional student billet costs (salary, benefits, and living expenses) (PSC) attributed to CMI training for the A graduates are:

$$PSC = \frac{A(MHS)(P)(BC)}{MHW}$$

where PSC = Proportional Student Costs attributed to training

A = Number of Graduates

---

[1] The ship familiarization phase has been omitted in this illustration.

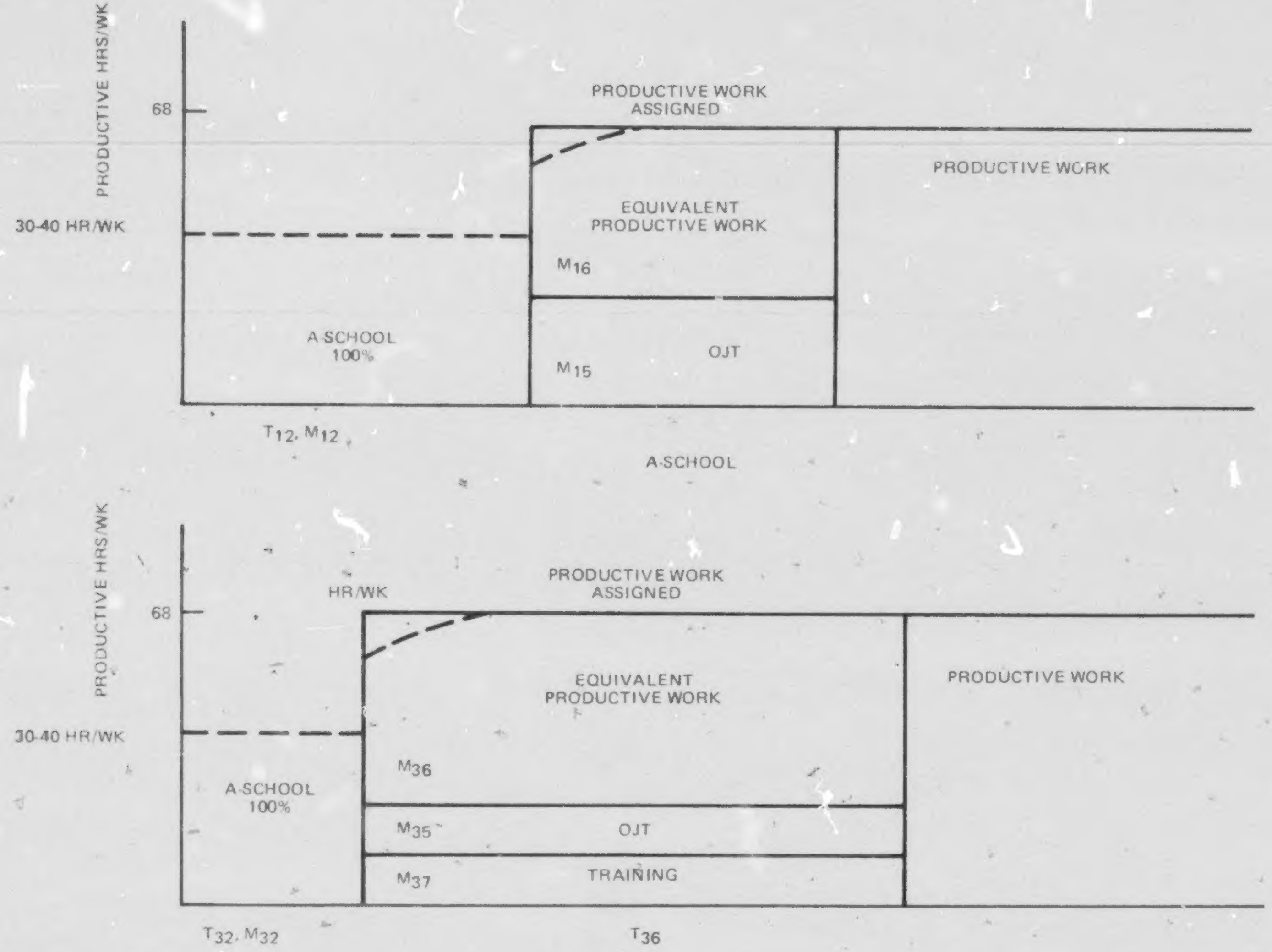
PRODUCTIVE HRS/WK
68
30-40 HR/WK
PRODUCTIVE WORK ASSIGNED
PRODUCTIVE WORK
EQUIVALENT PRODUCTIVE WORK
M16
A-SCHOOL 100%
M15
OJT
T12, M12
A-SCHOOL
PRODUCTIVE HRS/WK
HR/WK
PRODUCTIVE WORK ASSIGNED
68
30-40 HR/WK
EQUIVALENT PRODUCTIVE WORK
PRODUCTIVE WORK
M36
A-SCHOOL 100%
M35
OJT
M37
TRAINING
T32, M32
T36

Figure VII-4. Work Schedules for Scenarios 1 and 3

MHS = Average Man-Hours required to successfully complete the course

P = Proportion of work time devoted to course training

BC = Total Billet Cost (weekly salary, benefits and living expenses)

MHW = Average Man-Hours per Week of training performed

Following are examples of how this calculation is to be made:

a. Case 1: CONUS Schoolhouse Training

Assume that:

- At the CONUS schoolhouse a course requires an average of 240 hours (MHS) for each of 400 graduating students (A) to complete.
- Each student goes to school an average of 30 hours per week (MHW) and this constitutes a full time work assignment (P = 1).
- Total salary, benefits and living expenses are $300 per week (BC).

Thus, $PSC = \frac{(400)\ (240)\ (1)\ (\$300)}{(30)}$ = $960,000 for 400 successful graduates.

b. Case 2: Shipboard Training

Assume that the 400 graduates had been on board ships, had taken the courses for ten hours per week on duty time, and that the total course required an average of 300 man-hours. The proportional student costs for the 400 graduates attributed to training would be found as follows.

The average number of weeks required to complete is 300/10 = 30 weeks. However, only P proportion of these 30 weeks total salary is chargeable to training. Assume the total standard work week for a watch stander is 74 hours, of which six hours are devoted to military training and service diversions. Hence, these six hours can be considered as overhead to both the work and the training. Thus, the proportion of total available work time chargeable to training is:

$$P = \frac{10}{68} = .147$$

Hence, $PSC = \frac{(400)\ (300)\ (.147)\ (\$300)}{10} = \$529{,}200$ for the 400 graduates.

c. Case 3: Shipboard Training

In Case 2, if the 400 graduates spent ten hours per week taking the courses, but only five hours per week on duty time (the other five hours per week on "free time"), P is now equal to .0735 and,

$$PSC = \frac{(400)\ (300)\ (.0735)\ (\$300)}{10} = \$264{,}600$$

However, salary, benefits and living expenses for non-graduates must also be paid for the B non-graduates while they are attending the course. Therefore:

let $$PSN = \frac{(B)\ (MHN)\ (P)\ (WS)}{MHW}$$

where PSN = Proportional Student Costs of B non-graduates

MHN = Average man-hours of training performed before attrition.

P, WS and MHW are defined as before.

Thus, TSC, the total student costs for the A graduates, is TSC = PSC + PSN.

It should be explicitly noted that in this analysis we are including the cost for all students who do not graduate from the course.

However, we are not assigning any benefits for those who attrite. This is a reasonable assumption since attrition, in general, takes place early in the training period. This method of treating the costs of all non-graduates is based on the assumption that all non-graduates complete their enlistment at some other assignment. However, as indicated previously, if the service policy is to discharge non-graduates following their attrition from school, the cost of recruit training (including recruiting and transportation costs) must also be included in the cost analysis.[1]

5. Synergistic Effect of A-School, OJT and Work

A hypothesis which we make (and which requires statistical validation during the demonstration) is that an integrated program combining theory (A-school CMI), OJT and work assignments will enable a man to achieve a level of proficiency in less total training man-hours than taking theory first followed by both OJT and work assignments. Thus, in addition to measuring the man-hours to satisfactorily complete A-school, we should also measure the total man-hours to complete OJT (up to a given level of proficiency).

The following measurements will be conducted during the demonstration:

- Measure the man-hours required to complete A-school (M_{12} vs. $M_{32} + M_{36}$), as described previously.[2]
- Measure the man-hours required to reach various defined levels of competence through OJT and work done in parallel (M_{15} and M_{35}). While OJT continues informally indefinitely, we shall, for the purposes of this analysis, define OJT in the same terms as a particular course. That is, the student keeps advancing over increasing levels of competence and is thus able to perform increasing sets of tasks. With this in mind, we would

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[1] The Air Force has such a policy.

[2] This analysis is made comparing the first and third scenarios of Figure VII-3.

like to measure the time taken to reach certain levels of competence through OJT and work experiences. Obviously, M_{15} and M_{35} will themselves vary as the competency level parameter changes.

- Determine the equivalent man-hours of unproductive time lost during the man-hours assigned for productive work (M_{16} vs. M_{36}).

By Productive Work we mean all work tasks done which are part of the normal day-to-day duties (even if they are accomplished within the context of OJT). On the other hand, pure OJT activity may include typical work elements, but they are only done as practice. For example, a student may practice tuning a transmitter (off-line, main power or high voltage off). This time is counted as part of OJT training. On the other hand, when he advances to the point that his supervisor asks him to tune the transmitter for actual operation under a petty officer's supervision, the student's time is counted as productive, and the supervisor's time is counted as OJT training supervision.

By Equivalent Unproductive Man-hours we mean that amount of the man's time when he was available for productive work (M_{16} and M_{36}) but could not perform productively, either because of a lack of productive work at his skill level, or because he took longer to do the work than some reasonable time standard because of his skill level. Obviously, this is determined by these factors:

-- The supervisor assigning work to the student in accordance with his current capabilities as he progresses through course training and OJT.

-- The capability mix of the entire Division. If the proportion of new students is too high, the available lower level work may be insufficient to fully occupy this group, and the equivalent productive work load will be as shown by the dotted lines of Figure VII-4. This problem decreases as time goes on and the capabilities of the students increase.

To maximize the productive work obtained from these semi-trained students, some restructuring of the Division's work duties may be required. Figure VII-5 shows a "frequency distribution" of the total work load in a division such as the Communications Division. This figure represents a listing of all work tasks being done in the division, ranked from the least complex to the most complex (the way OJT would probably

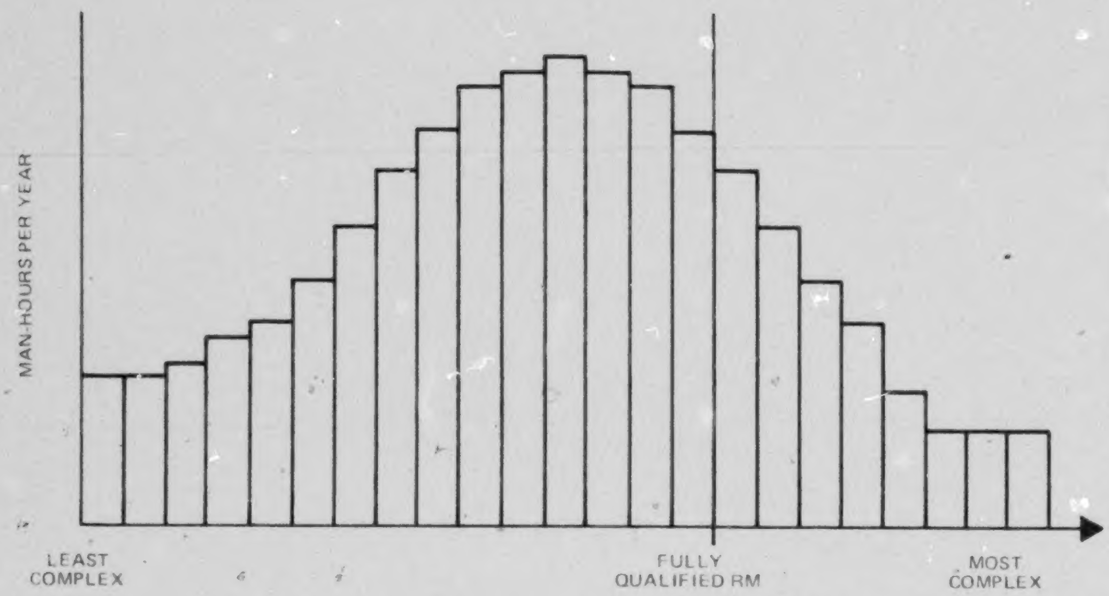

Figure VII-5. Work Task Distribution in Division

be taught), and the amount of man-hours per year required by each task. We also show all of the tasks which a fully qualified individual (one who completes the level of training and OJT previously defined) can do. Since a member of the division assigned to OJT progresses from left to right in his qualifications as he advances in his OJT program, it should be possible, by relating each trainee's work assignments to his progress through OJT, to reduce the Equivalent Unproductive Time to nearly zero. Since the fleet is currently manned at some factor less than 100%, if additional manning (say up to the 100% level and taking into account bunk constraints) were transferred from CONUS A-school to the ship for training as well as productive work, the amount of productive work capability would be increased accordingly based on the following assumptions (to be validated during the demonstration):

- There is sufficient lower level work to be done so that work assignments could be adjusted within the division to utilize the students as they progress through OJT.
- The extra man-hours required to supervise the students during OJT and their productive work is not excessive.

Thus, the final analysis of each operational system would contain the following data:

- The man-hours required to complete A-school.
- The man-hours required to complete a given level of OJT.
- The man-hours of productive work provided by the students, converted to additional men "on board."
- The man-hours required by the OJT supervisor.

E. Calculating Training System Costs

This section of the report will describe how to estimate all of the other costs required to develop (both equipment and software), acquire, install, operate, maintain and support each system alternative considered during its entire system life.

The systems analyst, working with a designated contact point at:

- The CMI computer center
- A typical schoolhouse
- The CMI minicomputer system project

will design each system alternative for varying system demands and determine the resources required for each alternative design. To aid the system designers in systematically gathering and storing the data required, it is suggested that the data for each system design be accumulated in a matrix format similar to that shown in Table VII-1. Basically, Column 1 lists the names of all resources to be used over the entire system life, with columns 3, 4 and 5 listing the amount of each resource expended over time (Column 3--Pre-Operations, Column 4--Each Year

Table VII-1. System Design and Cost Data Base

SYSTEM DESIGN ALTERNATIVE NO ________

SYSTEM DESIGNATION ________________

RESOURCES REQUIRED

(1)	(2)	(3)			(4)			(5)			(6)	(7)
SYSTEM ENTITIES	NUMBERS OF EQUIPMENT REQUIRED	PRE OPERATIONS			OPERATIONS, MAINTENANCE AND SUPPORT (Per Year)			POST OPERATIONS (RESIDUAL VALUE)			BILLET TITLE	ADDITIONAL BILLETS REQUIRED
		Time	Man-Hours	Dollars	Time	Man-Hours	Dollars	Time	Man-Hours	Dollars		
1.0 EDP System												
1.1 EDP System Operations												
1.1.1 Equipment												
1.1.2 Materials and Supplies												
1.1.3 Personnel												
1.1.4 Facilities												
1.2 EDP System Maintenance												
1.2.1 Equipment												
1.2.2 Materials and Supplies												
1.2.3 Personnel												
1.2.4 Facilities												
1.3 EDP System Support												
1.3.1 Equipment												
1.3.2 Materials and Supplies												
1.3.3 Personnel												
1.3.4 Facilities												
2.0 Communications System												
2.1 Communications System Operations												
2.1.1 Equipment												
2.1.2 Materials and Supplies												
2.1.3 Personnel												
2.1.4 Facilities												
2.2 Communications System Maintenance												
2.2.1 Equipment												
2.2.2 Materials and Supplies												
2.2.3 Personnel												
2.2.4 Facilities												
2.3 Communications System Support												
2.3.1 Equipment												
2.3.2 Materials and Supplies												
2.3.3 Personnel												
2.2.4 Facilities												
3.0 Instructional System												
3.1 Instructional System Operations												
3.1.1 Equipment												
3.1.2 Materials and Supplies												
3.1.3 Personnel												
3.1.4 Facilities												
3.2 Instructional System Maintenance												
3.2.1 Equipment												
3.2.2 Materials and Supplies												
3.2.3 Personnel												
3.2.4 Facilities												
3.3 Instructional System Support												
3.3.1 Equipment												
3.3.2 Materials and Supplies												
3.3.3 Personnel												
3.3.4 Facilities												

of Operations,[1] Column 5--Post-Operations, giving the residual value of any investment resources remaining). Hence, the amount of each resource required over time can be inserted in the appropriate entry of the matrix.[2] The following steps will be followed in accumulating the data required:

1. Classify all entities which comprise the system alternative.

Column 1 of the table lists the various entities and other resource categories comprising the system in a three-level hierarchical form. The first level consists of the three main system functions, as listed:

- EDP System
- Communications System
- Instructional System

Under each system function are listed the three key system subfunctions requiring resources:

- Operations
- Maintenance
- Support

The third level consists of the four major categories of entities which are needed to implement each subfunction:

- Equipment, including any interface equipment required (which should be listed under the most appropriate sub-system), as well as computer software.
- Materials and Supplies

---

[1] If the resources expended each year are not uniform, a separate entry will be made for each year of operations.

[2] Note that some entries will be empty since that resource is not required at that time.

- Personnel
- Facilities and Utilities (to house and support these entities)

Note that a hierarchical numbering system is to be used for each entity within the hierarchy. Any required entity or resource which cannot be included in this classification system should be included in a category labeled "other" or some more appropriate label. The main objective is to make certain that all entities are identified for later quantification. The systems analyst will work with the systems contact point in completing this table.

2. Determine how many units of each type of prime mission equipment (no spares) listed in Column 1 are required as a function of system capacity, and list in Column 2 along the appropriate row for System Operations.

The total capacity/size of the system is a function of the following key characteristics:

- The number of CONUS and remote sites to be operated (S)
- The number of students per year trained at each site (ST)
- The average amount of student learning hours per day at each site (LH)

Since the key objective of the analysis is to provide the decision makers with information concerning the total costs, as a function of these three characteristics, the basic resources data collected must also be collected as a function of these characteristics, as described below. This data will then be manipulated to show total costs for different system capacities.

Several examples of how Column 2 is to be completed for the different system designs are as follows:

- Satellite Terminal (if not supplied). One may be required per remote site.[1]
- Test Sensing Equipment (OPSCAN 17). One may be required per remote site.
- Student Terminal. A minimum of one terminal may be required at each remote site when the minicomputer system is used, or if the Navy communications system is not used. However, if the number of student instruction hours exceeds a certain level, additional student terminals may be required. The need for such additional terminals for obtaining student replies in "real time," as opposed to batch processing, may be calculated as follows:

  While a terminal is theoretically available for student use 1,440 minutes per 24-hour day, even with close system control (such as setting appointments for given amounts of time to prevent excessive waiting time to use the terminal), one terminal cannot be utilized this efficiently (or an infinite waiting line would result). Current practice in the schoolhouse or the demonstration must determine the maximum acceptable usage obtainable from a terminal (in minutes per day) before a second terminal is required. This upper limit will be a compromise among such factors as the number of students using the terminal, average hours of student instruction per day, the student "control system" used, to minimize waiting, and the maximum amount of student waiting time which will be acceptable. Suppose that for a given type of student control it is found that one terminal can be used for a maximum of only 500 minutes per day if undue amounts of student delays are to be avoided. We must next compare the average estimated student usage with this threshhold level to see if it will be exceeded. This calculation, shown in Table VII-2, is made in the following fashion:

  -- List in Column 1 all courses which will be taken simultaneously.[2]

---

[1] Some system alternatives may link remote sites together by some form of communications and hence only require one satellite terminal for a cluster of sites.

[2] Since the objective of this calculation is to determine the maximum terminal usage required, if the total student workload is apt to change over the next year, several calculations may be required to find this maximum.

Table VII-2. Calculating Terminal Usage

(1)	(2)	(3)	(4)	(5)	(6)
Course Title	Average Student Instruction Time Per Course (Hrs)	Average Student and Instructor Terminal Time Per Course (Minutes)	Number Students Simultaneously Enrolled In Course	Amount of Student Instruction Per Course (Hours Per Day)	Total Terminal Time Per Day (Minutes Per Day)
Avionics	500	400	10	2	(10)(2/500)(400) = 16 min.
Aviation Machinist Mate	1,000	600	20	5	(20)(5/1000)(600) = 60 min.
Total Time					76 min.

-- List in Columns 2 and 3 the average student instruction time required (in hours) for each course listed.

-- List in Columns 4 and 5 the number of students taking instruction in each course, and the amount of instruction time taken each day.

-- Calculate in Column 6 the total student terminal time required per day for each course listed, as follows:

$$TT = (S)\ (ST/CT)\ (TTC)$$

where TT = Total terminal time required per day for the course in minutes (average value).

S = Number of students taking course.

ST = Student instruction time each day in hours.

CT = Total instruction time required for the entire course in hours, (average value).

TTC = Total terminal time required during the course in minutes, (average value).

-- Compare the total terminal time required per day (TT) with the maximum acceptable terminal time and if TT exceeds the maximum, additional terminals are required.[1]

---

[1] During the demonstration, this maximum value must be determined for one and more terminals. Theoretically, the value for n terminals will be greater than n times the value for one terminal.

Printer requirements may be calculated using the same method as described for the student terminal.

- Communications Requirements. Communications channel time requirements, as a function of student instruction hours, should be indicated.
- Maintenance, Test and Repair Equipment. The maintenance equipment required must be related to the prime mission equipment to be repaired. Its degree of sophistication (which helps determine the mean time to repair) should be based on the trade-offs among the following three items to minimize total maintenance subsystem costs and keep equipment availability within acceptable bounds:
  -- The maintenance equipment cost
  -- Man-hours per repair returned
  -- Maintenance personnel salaries

3. Determine how many units of each type of equipment listed in Column 2 are required as spares and list in Column 2 along the appropriate row for System Maintenance.

The number of spares required will be a function of:

- Operational Usage
- Frequency of Failure
- Mean Time to Repair
- Navy Policy

4. Determine if any of the required equipment will normally be located at the remote site and, if so, if it could be used by the training system.

The use of such equipment for training purposes will normally be determined by the amount of use required. Obviously, specialized equipment such as the OpScan 17 will have to be purchased. However, the need for a standard Navy teletype for a short time per day may permit the use of a spare available at the site.

The use of common purpose equipment such as AUTODIN presents special problems of costing. The amount of loading the training system produces on the communications system will determine if any additional costs will have to be borne by the AUTODIN system. If so, such costs must be charged to the training system.

The use of service-provided assets such as the Navy FleetSatCom system presents similar problems. Again, the key is to determine how much loading (in terms of Navy messages per day to be converted to required satellite time) the training system imposes. Several ways in which such costing has been handled in the past, depending on the scenario, are listed below:

- Option 1: The communications load is small and the capacity is available so that no other user is deprived. Hence, no costs should be allocated to the Training System.
- Option 2: If a user had been deprived of the communications channel and had to use alternative means of communications, this requires some cost which would not have had to be borne. Hence, this is the cost to be used.
- Option 3: An entire satellite system devoted to training is a straightforward option to cost since all of the costs are borne by the training system.
- Option 4: An expanded FleetSatCom system using spare satellites for training (until needed by a malfunction of the tactical satellite) is a more complex option to cost, since, by definition, the spares are needed anyway, yet can serve the additional function of training. If such use of the satellite would shorten its life, this loss could be charged to the training system. If not, it is free.

The appropriate way to be used in this project will be determined by our particular scenario, and will be confirmed after further discussions with TAEG, OP-124 and OSD Manpower and Reserve Affairs (Training).

5. Determine all resources required prior to the beginning of operations for such things as equipment or software development, acquisition, installation and training, and list each in Column 3 of Table VII-1 on the row of the entity it is associated with. Note that some rows will be empty (i.e., not requiring pre-operations resources).

Having determined which resources are required, the cost analyst will determine the cost of these resources as well as the time required to complete the function. Each resource requirement should be related to the number of system components involved.

Three measures of requirements are listed under each column. "Time" represents the total time in months required to complete the activity such as RDT&E, procuring prime mission equipment, or installation. It is also used to determine "Man-hours," the O&M manpower resources required. Lastly, "Dollars" are used to represent the out-of-pocket costs of each activity. Obviously, man-hours can be converted to the equivalent dollar cost, by knowing the rate of pay.

The systems designers should also provide some indication of the range of uncertainty in each estimate by providing three numbers: the expected value, the optimistic value, and the pessimistic value, if high uncertainty exists.

While Table VII-1 is an overall data collection form, all supplementary data explaining how the final data was arrived at should be attached as back-up information. Examples of such entries are:

- RDT&E Costs--A fixed value of cost, independent of student usage.
- Investment Costs--The cost of each piece of equipment as a function of volume, since the average unit cost of equipment may decrease as the volume increases.
- Installation Costs--A fixed value for each type of installation required.

- Facilities Required--The size and location of the facilities required, as a function of the type of remote location, the number of student-training hours per day and the equipment and materials involved.

- Training of Personnel--The cost of training personnel to operate, maintain and support the training system, as a function of the number of personnel required to be trained.

6. In the same fashion as described in Step 5, determine all resources required during the operational phase and list these in Column 4 in the appropriate row of Column 1. Again, certain rows will be empty. All resources should be listed on an annual basis. If annual costs differ from year to year, use a separate costing sheet for each year.

The systems designers will indicate the appropriate resources required for each of these activities, expressed as some function of system capacity/size. Five examples are described below.

a. Learning Supervisor Workload

The primary functions of the Learning Supervisor should be listed as back-up information and will probably include custody and distribution of instructional materials, counseling of students, and quality control checks of the system. The remote site may prefer to assign the administrative duties to the training officer, and the function of providing specialized technical assistance to one or more senior petty officers to whom the students are assigned for work duties. In such cases, these resource requirements must be included in the cost analysis so that any additional billets required may be added to the Ship Manning Document. The average instructor-student contact workload per week for any given course will have to be estimated as some fraction of the number of student-training hours on that course, extrapolating data obtained during the demonstration and from the current CONUS schoolhouse. Obviously, this total workload is the sum of contact hours over all courses being taken during the week.

b. Communications Operator Workload

If communications personnel are required to any major extent, over and above their normal duties, their workload applicable to this training system must also be included. For example, the communications operator primarily performs quality control (QC) checks, maintenance work (see next section), and message handling. The QC weekly work load can be estimated as the product of the average estimated unit time required for each QC check and the average number of QC checks made per week. The message handling workload can be estimated as the product of the average time required for each message (both originating and reply) and the average number of messages handled per week. In all three cases, the incremental man-hours required attributed to the training workload will be estimated.

c. Maintenance Workload

The man-hours required per year for each piece of equipment are determined by the Preventive Maintenance (PM) schedule and by unit times required. The Corrective Maintenance (CM) man-hours required are the product of the frequency of failure and the mean time to repair (which in turn depends on the maintenance test and repair equipment specified).

d. Support Workload

This workload is determined by the various types of support services required. It is the product of the unit time required for each service and the frequency of the service.

e. Supplies and Other Materials

These will be as required by system performance characteristics.

7. Determine the net resources available at the end of the assumed eight years of operations, and list these in Column 5 of Table VII-1 in the rows of the entities they are associated with. Again, some rows will be empty.

These net resources should include both expenditures for disassembly of equipment as well as the residual value (if any) of the equipment.

8. Determine the billet titles which will do the personnel workloads listed in Columns 3 through 5 and list this information in Column 6.

Part of the system design process is to cluster related work elements, thus defining all positions required. It is particularly important to note all new positions required, or if any work will be done by a position already assigned as part of the current system (including positions now at the remote site).

9. Determine the additional number of billets required and list this information in Column 7.

By summing the number of man-hours per week required for each activity done by the same billet title (for a given size system), we shall find the total work load for each billet. Dividing this by the standard work time available in the standard work week, we can find the number of billets required for each billet title,[1] and the additional number of billets required for each system design.

F. Determining Total System Life Costs

1. Calculations

We shall now describe how to combine the training system cost data base of Table VII-1 and the student associated costs previously described to calculate the total cost stream over the entire system life for each system alternative being analyzed. In making such a calculation, the following considerations must be taken into account:

---

[1] Watch standers are treated on the basis of the standard number of men required for each watch position.

- Total system costs are a function of system capacity.
- System costs have two elements: man-hours per year, which will have to be converted to billets, and total non-manpower dollars per year. By factoring in billet costs, the total system costs can be expressed as equivalent dollars per year.
- Total system costs are a function of the assumed system life.
- Total system costs of each alternative must be compared.

The total costs for each system alternative will be compared with one another on the same basis. Each of these elements will now be described.

a. Total System Costs Are a Function of System Capacity

As indicated previously, the total costs of each system will be a function of three basic parameters:

- Number of remote instructional sites activated.
- Number of students being trained per year at each site.
- Amount of student instruction per year at each site.

To permit the decision makers to examine as many options as they desire, total costs shall be calculated as the sum of four main costs as shown in Figure VII-6.

- Cost 1 is the total cost associated with the central CMI system in Memphis, and consists of two parts. Cost 1.1 comprises the fixed costs of the central CMI system which must be borne irrespective of the number of remote sites, the amount of courses actually used at these sites, the number of students, and the rate at which they take instruction. One such example is the cost of developing and coding a CMI course. Cost 1.2 comprises the additional costs of central CMI system which are incurred because of the three basic parameters (number of remote sites activated, students and instruction rate).

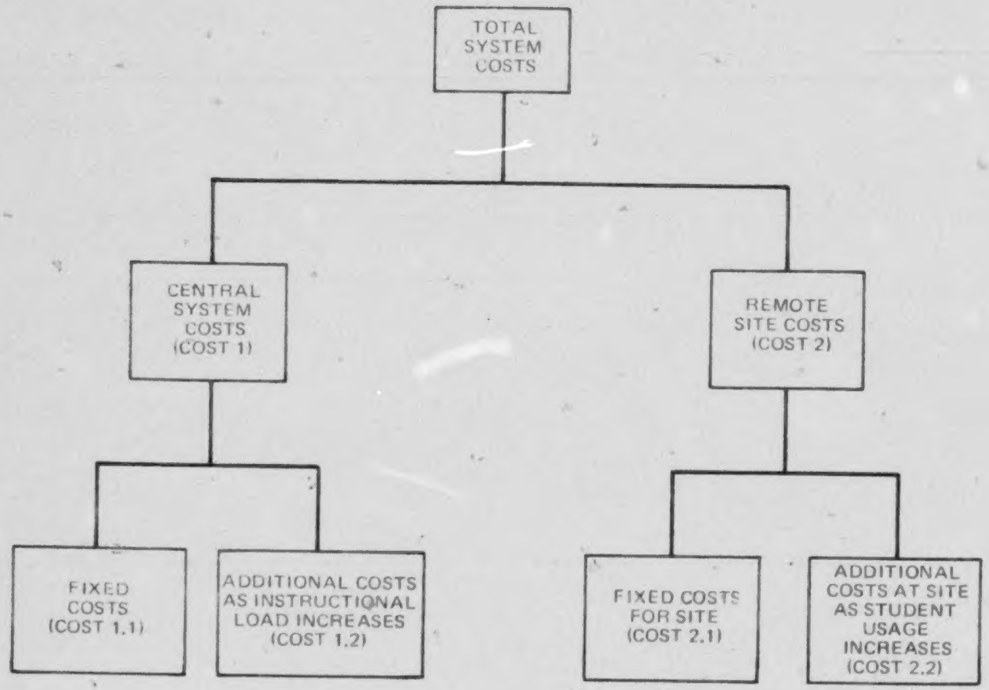
TOTAL SYSTEM COSTS
CENTRAL SYSTEM COSTS (COST 1)
REMOTE SITE COSTS (COST 2)
FIXED COSTS (COST 1.1)
ADDITIONAL COSTS AS INSTRUCTIONAL LOAD INCREASES (COST 1.2)
FIXED COSTS FOR SITE (COST 2.1)
ADDITIONAL COSTS AT SITE AS STUDENT USAGE INCREASES (COST 2.2)

Figure VII-6. Structure of Total System Costs

- Cost 2 is the total cost of each remote site, and also consists of two main parts. Cost 2.1 comprises the fixed costs associated with the procurement and installation of all equipment for a standard minimum size learning center at a particular site,[1] including:
  - -- Satellite terminals at each remote site (if not already provided by some other communications need at the site).
  - -- Standard-sized, outfitted learning center (appropriate to the particular type of remote site).

  Cost 2.2 consists of all other costs associated with number of students and instruction rates, including all the additional costs of an enlarged learning center for more students, including additional terminals required, all operations, maintenance, support and personnel costs since they depend on the number of student usage.

---

[1] Obviously, these costs may be different for a carrier as compared to a destroyer, since this minimum size may vary.

Thus, the total cost of all remote sites equals the sum of the Cost 2 elements for each of the remote sites involved.

b. System Costs Have Two Elements

With the four main costs of Figure VII-6 in mind, the cost stream of any given option may now be calculated as follows:

- Start with the annual costs associated with Cost 2.1 (for each type remote site). Determine the total dollar costs to include the cost of the total additional billets required[1], as obtained from Table VII-1.
- Next, calculate Cost 2.2, the total annual costs as a function of different amounts of students and usage (as measured in student-hours of training per year) as also obtained from Table VII-1.
- Next, calculate the total annual costs associated with Cost 1.1, including course development.[2]
- Next, calculate the total annual costs associated with Cost 1.2, as a function of the number of remote sites and student usage.

c. Total System Costs Are a Function of the Assumed System Life

Most cost analyses of this type assume a time horizon for operations and maintenance of at least five years. TAEG (CNET's Training Analysis and Evaluation Group) has recommended a cost analysis on the basis of eight years of operations. Generally, the planning horizon is long enough that any residual value of the equipment can be ignored since dismantling and shipping and the discount factor reduces this value generally to a negligible amount. If, for a particular system alternative, this assumption is not true, the system designer should make certain that he provides an estimate of the residual equipment value in Column 5 of Table VII-1 so that it can be included in the cost analysis.

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[1] Manpower resources required can be separated from dollar costs if desired.

[2] This, and other non-differentiating costs, could be excluded if a more simplified cost analysis is acceptable.

d. Total System Costs Must Be Compared

The total cost stream associated with each system alternative, configured to provide the same number of student graduates each year, will be presented and compared with one another. The total system life cost stream associated with each system design will also be used to make the following additional cost calculations:

- Present Value of Total System Costs. This cost is the discounted value of the total system life costs for each alternative configured to provide the same number of student graduates each year. This cost will be calculated by using the cost stream calculated previously (with manpower costs converted to equivalent dollars), and an appropriate value for the discount rate. Ten percent is generally used for this type of system, as indicated by OSD.

- Present Value of Remote Site Costs. Another cost calculation which should be important to a decision maker is the incremental cost of a remote site as a function of student usage (present value of Cost 2). This can be obtained as a total cost stream (as a function of student usage) and then converted to a present value using the discount rate. The results expected for the latter type of calculation are illustrated in Figure VII-7. The locations of the break points shown are particularly important since they show design limits where additional entities are required.

- Average Cost per Hour of Student Training. This may be calculated by dividing the Present Value of Total Costs by the total number of student hours of instruction (or its present value) given to successful graduates only, taking into account system attrition. In general, the cost per hour diminishes as student usage increases.

2. Concluding Remarks

At the beginning of this chapter, we identified nine differences which exist among the system alternatives. Six of these differences were treated as factors which were then translated into cost streams for a given (eight year) student training load, each cost stream contributing to the total system cost stream. The six factors are:

- Factor 1, the Student Training Time in the Course, and Factor 2, the number of productive hours in the Standard Work Week. These are combined in determining the total Student Billet Costs while the student is enrolled in the course.

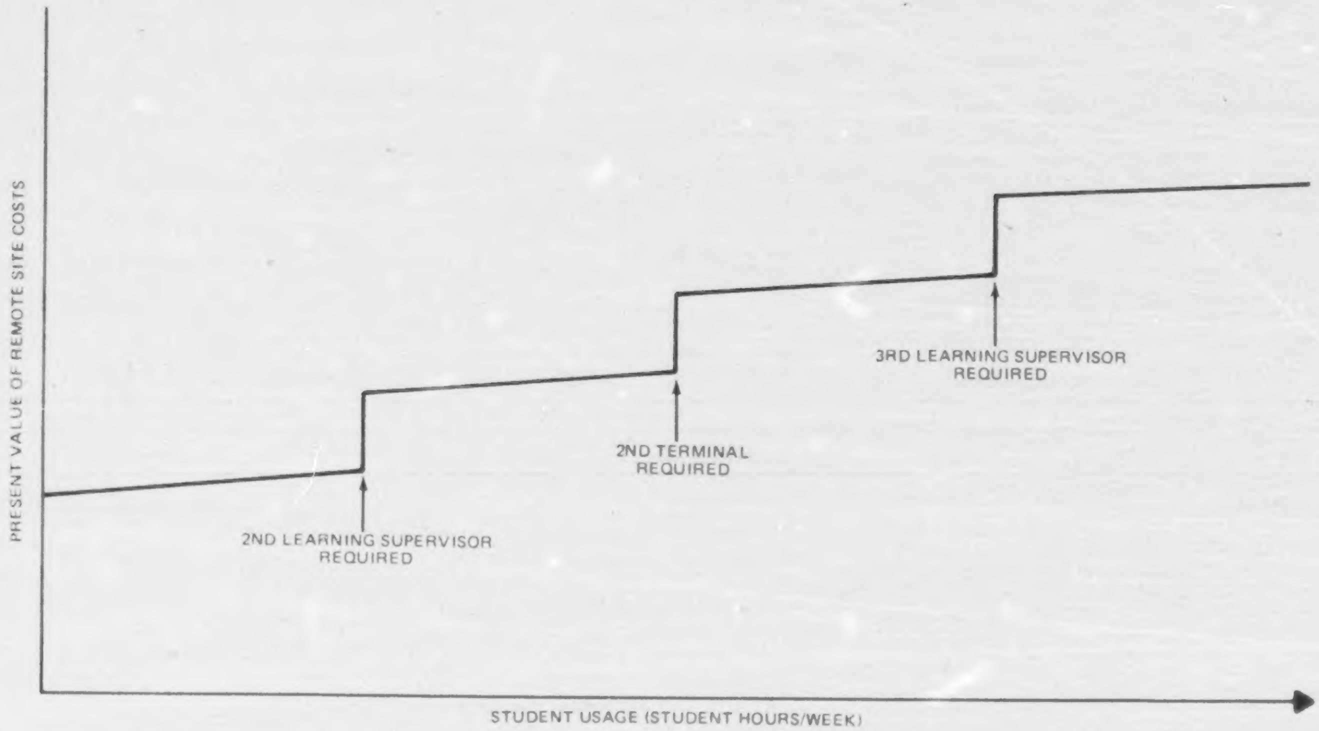

Figure VII-7. Present Value of Remote Site Costs

- Factor 3, Other Student Costs (transportation and living expenses while traveling).
- Factor 4, Student Attrition Costs.
- Factor 5, Student Time in OJT.
- Factor 6, Training System Costs.

The remaining factors, 7, 8 and 9, may be expressed in nonmonetary terms. Evaluation of these benefits will be discussed in a later section.

G. Other Benefits Available

The preceding analysis takes into account the readily measurable differences among the different training system alternatives affecting the total cost of developing, installing, operating, maintaining, and supporting each system, as well as the total student costs to graduate the same number of students, taking into account differences in attrition and training time required to complete the different courses as well as different standard work weeks in force at different training sites. As mentioned previously, there are several other differences between CONUS schoolhouse training and remote site training which may yield additional benefits for remote site training. These include:

- Additional manning at remote sites (Factor 7).
- Differences in training effectiveness (Factor 8).
- More training opportunities (Factor 9).

These differences among systems may be evaluated in the following ways:

1. Additional Manning at Remote Sites

If the current system trains these students at schoolhouses, and job site training will bring some of these students to the job site where they are available for work, this benefit may be measured as the additional productive work obtainable per year (non-training man-hours in peace time; all man-hours in a contingency when training will cease). These times can be converted into the average additional manning available to the unit.

While this additional manning does have a monetary worth (the current equivalent cost of manpower), and some analysts might evaluate this benefit by subtracting the value of the additional manpower from the total cost stream, it is not really an out-of-pocket saving which such a subtraction would represent. Hence, the additional manning will be kept as a separate measure.

2. Training Effectiveness

As indicated previously, it may not be possible to express this difference among systems quantitatively without extensive job-related performance evaluations.

3. More Training Opportunities

At the very least, we shall identify the number of personnel at remote bases for which programmed CMI courses could offer training opportunities for which the only alternative--a return to a CONUS schoolhouse--is not really available because of manning limitations. The impact of this training on operational readiness or re-enlistment rate could be estimated through quantitative survey techniques.

H. Sensitivity Analysis

Various analyses will be performed showing the differences in Total Costs among the alternatives as various factors or assumptions vary. While the total student usage per year and number of remote sites are the key parameters which have been identified thus far, the demonstration will identify others.

I. Developing The Master Plan

Based on the analysis described, a decision maker will be able to select the preferred system given the demand function of:

- Types of courses to be offered.
- Number of students to be trained (over time).
- Remote site where students may be located.

The time dimension will be inserted into the decision making process, and the transition plan will be developed.

Each of the alternative operational systems (except the current system) would have to be phased into the total Navy environment, requiring not only resources, but time for testing, development, procurement and installation for the number of operational sites involved. Hence, the results of the evaluation will indicate:

- The preferred system.
- The time phasing for implementing the preferred system at the desired remote sites, in accordance with the implementation strategies decided upon (part of the system design).

Since, in general, there may be considerable delay between now and when the preferred system will achieve Full Operational Capability (FOC), we shall also explore what transitional alternatives are available as well as find the preferred one. Such alternatives would include:

- Operate the current system until FOC is achieved by the preferred system.
- Go from the current system to one or more intermediate systems and then to the preferred system.

The cost and benefits of each transition plan will be calculated using the economic model described.

Chapter VIII

TASKS AND SCHEDULE FOR CONDUCTING A DEMONSTRATION

A. Introduction

Discussed in the first section of this chapter are the factors which influence the schedule and time frame for the design, preparation, execution and evaluation of the COMISAT demonstration. In the second section the tasks which need to be executed during each phase are presented.

B. Schedule

At the outset of the Feasibility Study in April 1976, it was expected that the key tasks and the schedule for execution would be as shown in Figure VIII-1. Specifically, it was assumed that the Feasibility, Design, and Preparation phases and their tasks would take 9, 4, and 6 months, respectively, with the Demonstration Phase scheduled to begin in November 1977. To keep the November 1977 starting date, certain conditions had to be met during the Feasibility Phase.

As was noted in Chapter II, the conditions that needed to be met to keep the task schedule included:

- Approval of a demonstration site(s)
- Acceptance of an existing or soon to be existing CMI course by the demonstration site
- A determination as to whether new or existing personnel would serve as demonstration subjects
- Approval for the use of an existing communications system
- Approval to use the U.S. Navy computer center at Millington, Tennessee

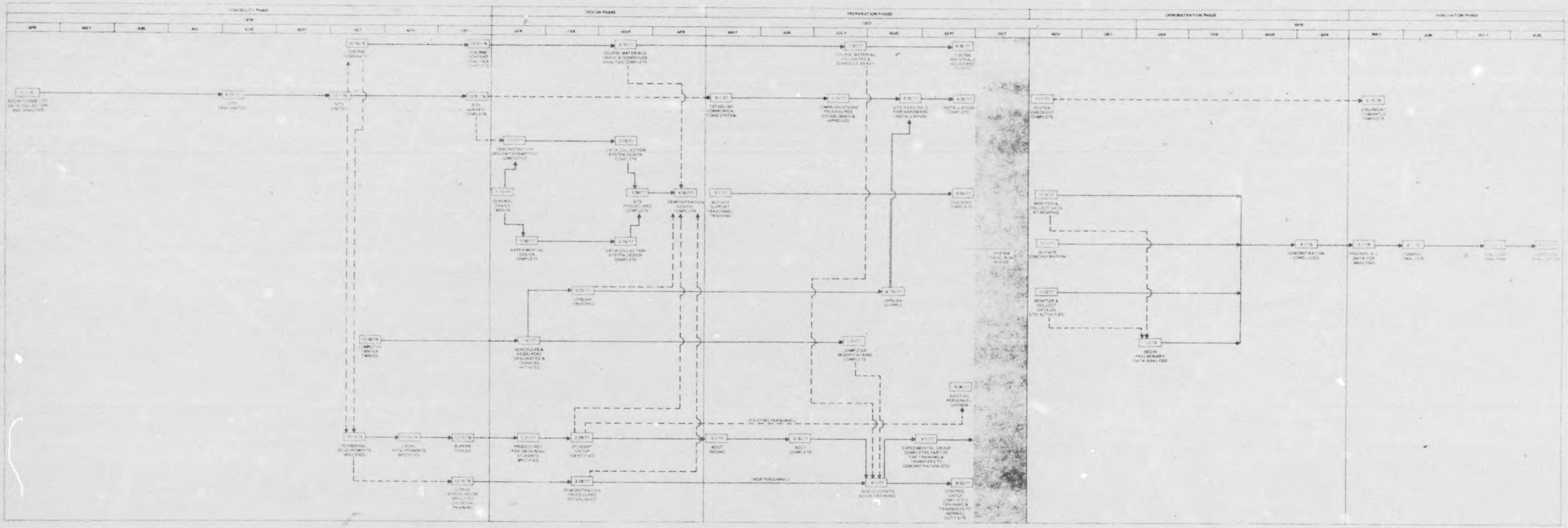
FEASIBILITY PHASE
DESIGN PHASE
PREPARATION PHASE
DEMONSTRATION PHASE
EVALUATION PHASE
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
BEGIN FEASIBILITY DATA COLLECTION AND ANALYSIS
SITE DESIGNATED
SITE VISITED
COURSE DESIGNATED
COURSE CONTENT ANALYSIS COMPLETE
SITE SURVEY COMPLETE
GENERAL DESIGN BEGUN
EXPERIMENTAL DESIGN COMPLETE
DATA COLLECTION SYSTEM DESIGN COMPLETE
SITE PROCEDURES COMPLETE
DEMONSTRATION DESIGN COMPLETE
OPSCAN ORDERED
OPSCAN DELIVERED
INSTALLATION COMPLETE
TRAINING COMPLETE
SYSTEM CHECKOUT COMPLETE
INITIATE DEMONSTRATION
DEMONSTRATION CONCLUDED
BEGIN PRELIMINARY DATA ANALYSIS
PERSONNEL REQUIREMENTS SPECIFIED
BUPERS TASKED
STUDENT GROUP IDENTIFIED
BOOT BEGINS
BOOT COMPLETE
EXISTING PERSONNEL CHOSEN
DEMONSTRATION PROCEDURES ESTABLISHED

Figure VIII-1. Original Task Schedule

While the latter two conditions have received tentative approval, the first three remain to be achieved and will impact the execution of all tasks associated with conditions 3 and 4.

1. Assessment of Original Schedule

To keep the original schedule and stay within the project time frame would require that the first three conditions be met immediately upon initiation of the Design Phase. Further, it would require that existing site personnel and an existing course of the appropriate length be used. Moreover, if the computer center could be tasked at the outset of the Design Phase, there would be a chance for meeting the September 30, 1977 deadline; however, this would be dependent upon the center having the required resources available to concentrate on the COMISAT project.

If the above conditions are not met at the outset but at some reasonable point during the Design Phase, there still could be a chance for meeting the original demonstration start date of November 1, 1977. However, this would require an overlap between the Design and Preparation Phases, since the design time period was based on the assumption that all conditions would be met during the Feasibility Study.

2. Schedule Slippage

As indicated above, it is unlikely that the original schedule can be kept if new personnel are used as demonstration subjects. Discussions with BUPERS indicated that little can be accomplished until a demonstration site is designated. At that point, if new personnel are to be used, negotiations would need to be conducted with the associated command and CNET relative to the demonstration subjects in such matters as:

- Arranging for site absorption of subjects at the completion of the demonstration
- Gaining approval for subjects' assignment as additions to normal site billets during the demonstration

- Insuring that subjects not be penalized in their advancement, vis-a-vis their peers, for participating in the demonstration
- Insuring that site billet rate requirements not be jeopardized by filling them with less qualified personnel
- Phasing demonstration subjects out at the end of duty tour

After these and other related items have been addressed, demonstration subjects would need to be identified. If they are personnel just entering the Navy, recruiting contracts would need to reflect their involvement in the demonstration. If they are recruits already in the Navy, recruiting contracts would need to be reviewed to insure that there would be no violation of contract; further, it would be necessary to gain their approval to participate as subjects.

This overall effort could take 6 to 9 months after the demonstration site is identified. Consequently, if the project is to have a reasonable chance of avoiding major schedule slippage, a demonstration site would need to be identified early in the Design Phase; of course, if a site is not designated during the phase, the project should be terminated. The identification of a site 2 to 3 months into the Design Phase would probably translate to a January or February 1978 start date.

Another factor which could influence the start of the demonstration would be the desire of the demonstration site to start on another date. For example, in discussions with Atlantic and Pacific fleet personnel it was learned that November may be an inappropriate time to initiate the project due to the upcoming holiday season. While no contact was made with land site personnel, it is likely that the same consideration would apply.

In sum, while it may be possible to stay within the original project time frame, the site itself may desire a January 1978 start date; and in light of the current slippage in meeting the conditions for an earlier start date, it may be propitious to plan to take advantage of the two additional months. Figure VIII-2 shows a related task schedule (excluding the Feasibility Study Phase, which has been completed). This schedule, and the additional two months it provides, is especially desirable if new, rather than existing, personnel are to be used as demonstration subjects.

3. New vs. Existing Course

The above discussion assumed that an existing course would be used. If this should not be the case and a new course has to be developed, there would be considerable impact on the project time frame.

Developing a new course from scratch and placing it on the NETISA computer system would take approximately 18 months: 10 to 12 months for the course IPD, and 6 to 8 months for the computer work, to include the interface for the demonstration. If work on a new course were started in January 1977 and existing personnel were used as the demonstration subjects, the demonstration could not possibly start until June or July 1978. Given a 6-month demonstration period followed by a 4-month evaluation period, the project would not end until May 1979.

The start date would be even later if a new course were combined with new personnel, who would receive a portion of their training at the CONUS schoolhouse before transferring to the demonstration site. For example, the students would start their training in June or July 1978, and assuming a 2-month CONUS training period, would not be ready to transfer to their assigned job site until August or September; then, due to leave, travel and settling-in time, another 6 weeks could pass before the demonstration could commence. Consequently, the start date would be about October 1978 and end close to August 1979. In other words, the project would end a year later than the originally planned date. It is doubtful that this much slippage could be tolerated.

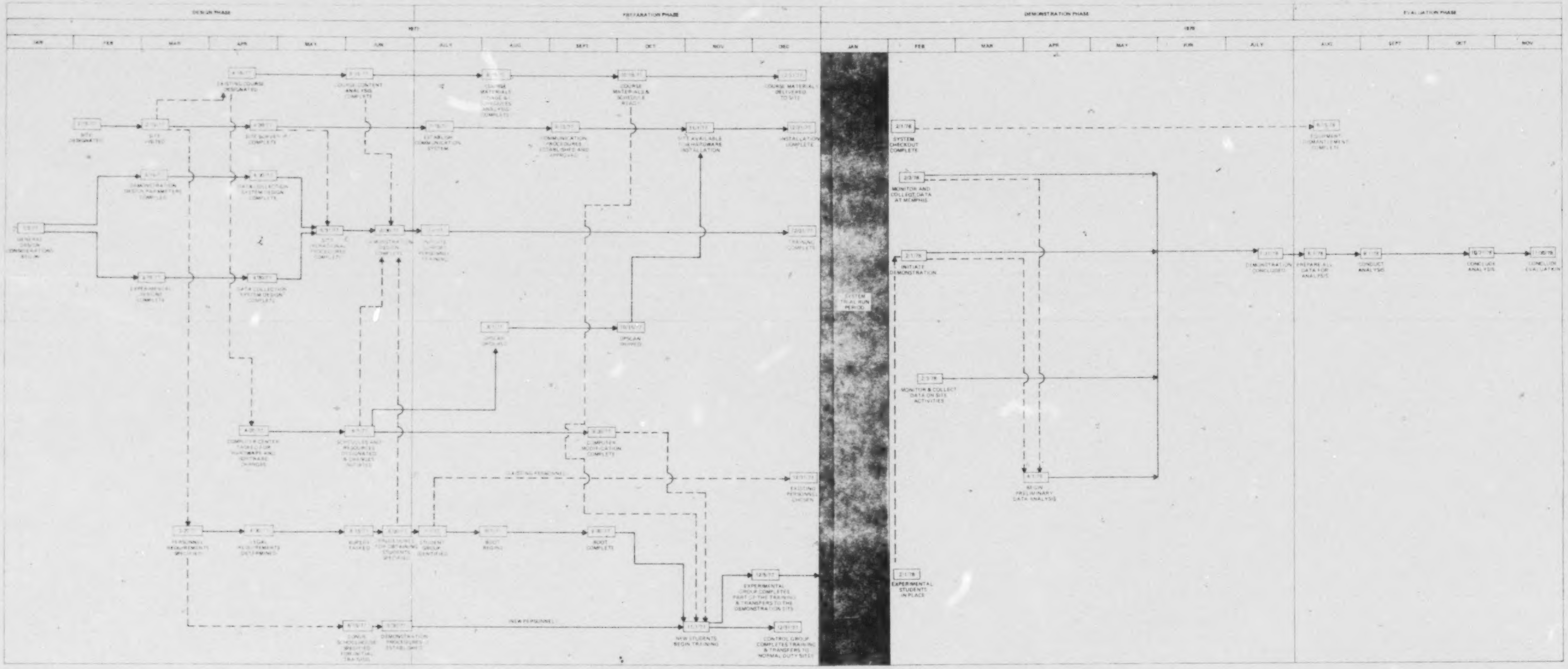
DESIGN PHASE
PREPARATION PHASE
DEMONSTRATION PHASE
EVALUATION PHASE
1977
1978
JAN
FEB
MAR
APR
MAY
JUN
JULY
AUG
SEPT
OCT
NOV
DEC
GENERAL DESIGN CONSIDERATIONS BEGUN
SITE DESIGNATED
SITE VISITED
EXISTING COURSE DESIGNATED
COURSE CONTENT ANALYSIS COMPLETE
SITE SURVEY COMPLETE
DEMONSTRATION DESIGN PARAMETERS COMPLETE
DATA COLLECTION SYSTEM DESIGN COMPLETE
EXPERIMENTAL DESIGN COMPLETE
DATA COLLECTION SYSTEM DESIGN COMPLETE
SITE OPERATIONAL PROCEDURES COMPLETE
DEMONSTRATION DESIGN COMPLETE
INITIATE SUPPORT PERSONNEL TRAINING
COURSE MATERIALS CHANGES ANALYSIS COMPLETE
COURSE MATERIALS & SCHEDULE READY
12/31/77
COURSE MATERIALS DELIVERED TO SITE
ESTABLISH COMMUNICATION SYSTEM
COMMUNICATION PROCEDURES ESTABLISHED AND APPROVED
11/1/77
SITE AVAILABLE FOR HARDWARE INSTALLATION
12/31/77
INSTALLATION COMPLETE
12/31/77
TRAINING COMPLETE
OPSCAN ORDERED
10/15/77
OPSCAN SHIPPED
COMPUTER CENTER TASKED FOR HARDWARE AND SOFTWARE CHANGES
SCHEDULES AND RESOURCES DESIGNATED & CHANGES INITIATED
COMPUTER MODIFICATION COMPLETE
EXISTING PERSONNEL
12/31/77
EXISTING PERSONNEL CHOSEN
PERSONNEL REQUIREMENTS SPECIFIED
LEGAL REQUIREMENTS DETERMINED
BUPERS TASKED
PROCEDURES FOR OBTAINING STUDENTS SPECIFIED
STUDENT GROUP IDENTIFIED
BOOT BEGINS
BOOT COMPLETE
12/5/77
EXPERIMENTAL GROUP COMPLETES PART OF THE TRAINING & TRANSFERS TO THE DEMONSTRATION SITE
NEW PERSONNEL
CONUS SCHOOLHOUSE SPECIFIED FOR INITIAL TRAINING
DEMONSTRATION PROCEDURES ESTABLISHED
NEW STUDENTS BEGIN TRAINING
12/31/77
CONTROL GROUP COMPLETES TRAINING & TRANSFERS TO NORMAL DUTY SITES
SYSTEM TRIAL RUN PERIOD
2/1/78
SYSTEM CHECKOUT COMPLETE
2/3/78
MONITOR AND COLLECT DATA AT MEMPHIS
2/1/78
INITIATE DEMONSTRATION
2/3/78
MONITOR & COLLECT DATA ON SITE ACTIVITIES
2/1/78
EXPERIMENTAL STUDENTS IN PLACE
4/1/78
BEGIN PRELIMINARY DATA ANALYSIS
8/15/78
EQUIPMENT DISMANTLEMENT COMPLETE
DEMONSTRATION CONCLUDED
8/1/78
PREPARE ALL DATA FOR ANALYSIS
9/1/78
CONDUCT ANALYSIS
10/?/78
CONCLUDE ANALYSIS
11/30/78
CONCLUDE EVALUATION

Figure VIII-2. Revised Task Schedule

4. Conclusion

In conclusion, given the strong possibility of schedule slippage due to the uncertainty over a demonstration site and the types of personnel to be used as subjects as well as the possible desire to start the demonstration in January 1978 rather than at the end of 1977, the time frame and schedule depicted in Figure VIII-3 seem appropriate for the execution of the remaining phases of the project.

C. Phase Tasks To Be Executed

Regardless of the time frame, a number of tasks need to be executed for each of the phases. During the Design Phase, a detailed plan for the preparation, execution, and evaluation of the demonstration would need to be developed. It would specify what is to be accomplished, where, when, how, and by whom. The key tasks would include:

- Develop research plan
- Design and develop formative evaluation plan
- Design economic research
- Design performance research
- Design attitude research
- Design Memphis computer facility operations plan
- Design communications system and operating procedures
- Design demonstration site operation
- Design site training hardware preparation and logistics plan
- Design site training center

The demonstration Preparation Phase would operationalize the design and test the plan to insure that all demonstration functions, procedures, etc., have been checked and are operating as required. Generally speaking, this would encompass the following tasks:

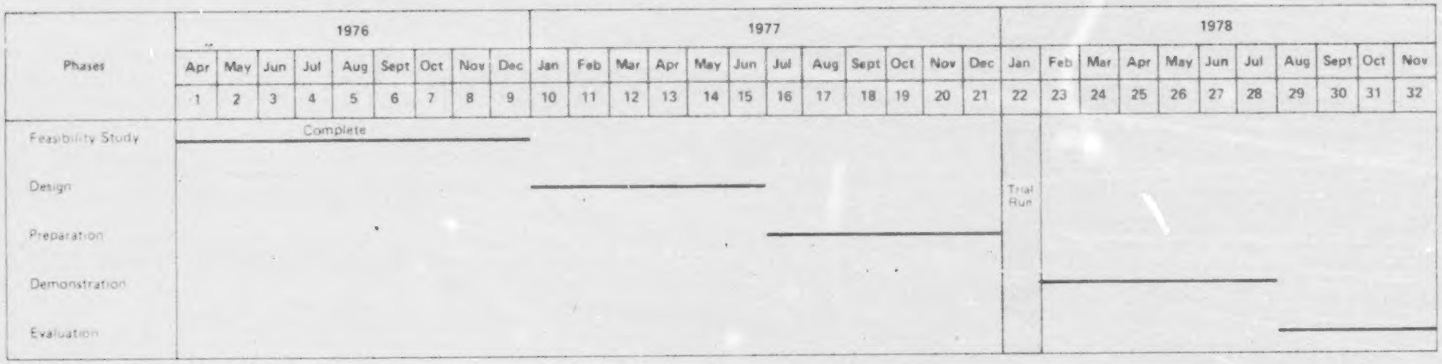

Figure VIII-3. Revised Project Schedule

- Implement formative evaluation
- Implement economic, performance, and attitude data collection plan and information processing procedures
- Prepare Memphis computer center for demonstration
- Install equipment at the site learning center
- Establish communications system and associated procedures
- Establish schedules and operating procedures for CMI training
- Conduct demonstration trial run

The Demonstration Phase would put all activities into action for demonstrating the COMISAT concept. Five basic tasks would be performed, to include:

- Initiate and conduct demonstration activities
- Monitor demonstration activities
- Collect site data and prepare analysis
- Collect Memphis CMI data
- Phase out demonstration and dismantle hardware

The final phase would encompass the summative evaluation. The output would provide information on student learning, attitudes, cost-effectiveness, organization and management, hardware, training, and options for an operational system. Further, a detailed specification for cost-effectiveness analysis of similar CMI computer telecommunication-distributed systems would be documented. Finally, a plan for an operational system would be provided. The three general tasks to be executed in this final phase would include:

- Prepare data/information for analysis
- Conduct analysis
- Produce final results and make recommendations for an operational system

Chapter IX

ALTERNATIVE COMMUNICATIONS SYSTEMS FOR THE OPERATIONAL SYSTEM

A. Introduction

To provide assurance that the CMI demonstration has been structured in a meaningful manner relative to the parameters and conditions under which an operational COMISAT system might function, the following preliminary description of an operational CMI system for shipboard or remote site use has been formulated. It includes consideration of the satellite and other communications systems that might be available on a worldwide basis, their geographical footprints, and the capacity of such systems to handle the additional message traffic generated by the CMI function. Also included is an initial look at the possible impact of existing Joint Chiefs of Staff (JCS) policies on the availability of communications facilities for an operational COMISAT system.

B. Operational System Data Requirements

This section describes the data requirements of the operational system, extending the analysis described previously for the demonstration system. These data requirements are a function of the following characteristics:

- Number of student training hours.
- Average number of characters in CMI message sent (same as demonstration: 82).
- Number of CMI messages sent in each batch (same as demonstration: 10, 20, or 30).
- Average number of characters in a CMI message reply. NETISA says this could be reduced to 600-800 characters in two ways.

First, an abridged form of reply could be developed, and these replies used as a separate track for remote students. Second, additional compression could be used, resulting in a 62-character line.

- Number of CMI message replies transmitted in each batch (same as demonstration: 10, 20 or 30).
- Batching the texts of the CMI message replies to use all or most of the 40 lines (2480 characters) available, thus providing highest communications efficiency.

To obtain an order of magnitude of the amount of data to be transmitted in an operational system, a "worst case" analysis[1] was performed based on the following values of these characteristics:

- Ten CMI messages sent would be transmitted in one batch. This results in 820 characters of text, and results from ten student training hours.
- Ten CMI message replies would be transmitted in one batch.
- Each CMI message reply would be assumed to have 801 characters, including the end of message symbol. Thus, the total batch of the 10 CMI message replies would contain 8,010 characters.
- Each Navy message reply would contain the maximum of 2,480 characters of text.

Based on these assumptions, the Navy message sent (consisting of 10 CMI messages sent) would contain 1,087 characters, and would be transmitted at an efficiency of 75.4%, as described previously.

The data requirements of the Navy message replies are calculated as follows:

- The total number of characters of text is (10)(801) = 8,010.
- The maximum number of characters of text in a Navy message reply is (62)(40) = 2,480.

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[1] Worst case in terms of the maximum amount of data to be transmitted. Similar analyses could be made for other sets of characteristics.

- The total number of Navy message replies is 8,010/2,480 = 3.23, or four messages. (This is equivalent to three messages of 2,480 characters of text and a fourth message of 570 characters of text.)
- The total number of characters of header and trailer in each reply message is 291.
- Thus, the total number of characters in the 4 Navy message replies is 8,010 + 4(291) = 9,174.
- The communications efficiency of the reply is 8,010/9,174 = 87.3%.
- Thus, the total data transmitted for ten student training hours = 1,087 + 9,174 = 10,261 characters.
- This equates to 1,026 characters per student training hour.

For ease of memory, a planner may wish to use this planning factor: Each training hour requires a round trip transmission of 1,000 characters. Note that this is less than one average Navy message of 1,200 characters.

Another way of expressing these requirements is as a percentage of the entire transmission capacity of a specific satellite. This is done for FleetSatCom, using a transmission capacity of 21.6 to 156 kb/s for the entire nine channels as described next.

Thus, in one 24-hour period, the total capacity of the satellite, assuming AUTODIN II requiring eight bits per character, is between:

$$\frac{(21.6\ \text{kb/s})(24)(3600)}{8\ \text{b/char.}} = 2.3328 \times 10^{8}\ \text{characters/day}$$

and

$$\frac{(156\ \text{kb/s})\ (24)\ (3600)}{8\ \text{b/char.}} = 1.6848 \times 10^{9}\ \text{characters/day}$$

Thus, each 1,000 student training hours/day in the satellite area requires between:

$$\frac{10^6 \text{ characters}}{2.3328 \times 10^8 \text{ characters}} = .0043 = 0.43\% \text{ of total capacity}$$

and
$$\frac{10^6 \text{ characters}}{1.6848 \times 10^9 \text{ characters}} = .00059 = .059\% \text{ of the total of the FleetSatCom satellite.}$$

Conversely, using 1% of the satellite would provide between 2,300 and 16,900 student training hours per day and using 10% of the satellite would provide between 23,000 and 169,000 student training hours per day. Both this and the previous functional relationship are shown in Figure IX-1, including the two limits of satellite capacity.

C. Systems To Be Available

A number of communications systems suitable for use by an operational CMI system have been identified and are discussed below. These communications systems fall into the following categories:

- Systems Using AUTODIN II Facilities
    - -- Systems for Shipboard CMI
        - o AUTODIN II, in conjunction with a satellite system (FleetSatCom or the Defense Communications System (DSCS)-II satellite).
        - o AUTODIN II, in conjunction with High Frequency (HF) transmission.
    - -- System for Remote Land Site CMI using AUTODIN II. The transmission facility will be determined by Naval Telecommunications System operators, based on traffic and propagation conditions, and may be satellite, HF, troposcatter, microwave, land line, or submarine cable.

- Systems Using Facilities Other than AUTODIN II
    - -- System for Shipboard CMI: Domestic satellite (Marisat), which provides commercial telephone facility connections and lines as part of its tariff.
    - -- System for Remote Land Site CMI (Note: Choice is dependent on location of land site):
        - o Commercial telephone facilities, possibly including the existing CMI telephone network. (Example: Remote land site within the contiguous 48 states.)
        - o Domestic satellite (Westar, RCA Satcom, Comstar, or American Satellite) plus commercial telephone facilities. (Example: RCA Satcom might be used for Adak, Alaska; Comstar might be used for Puerto Rico.)

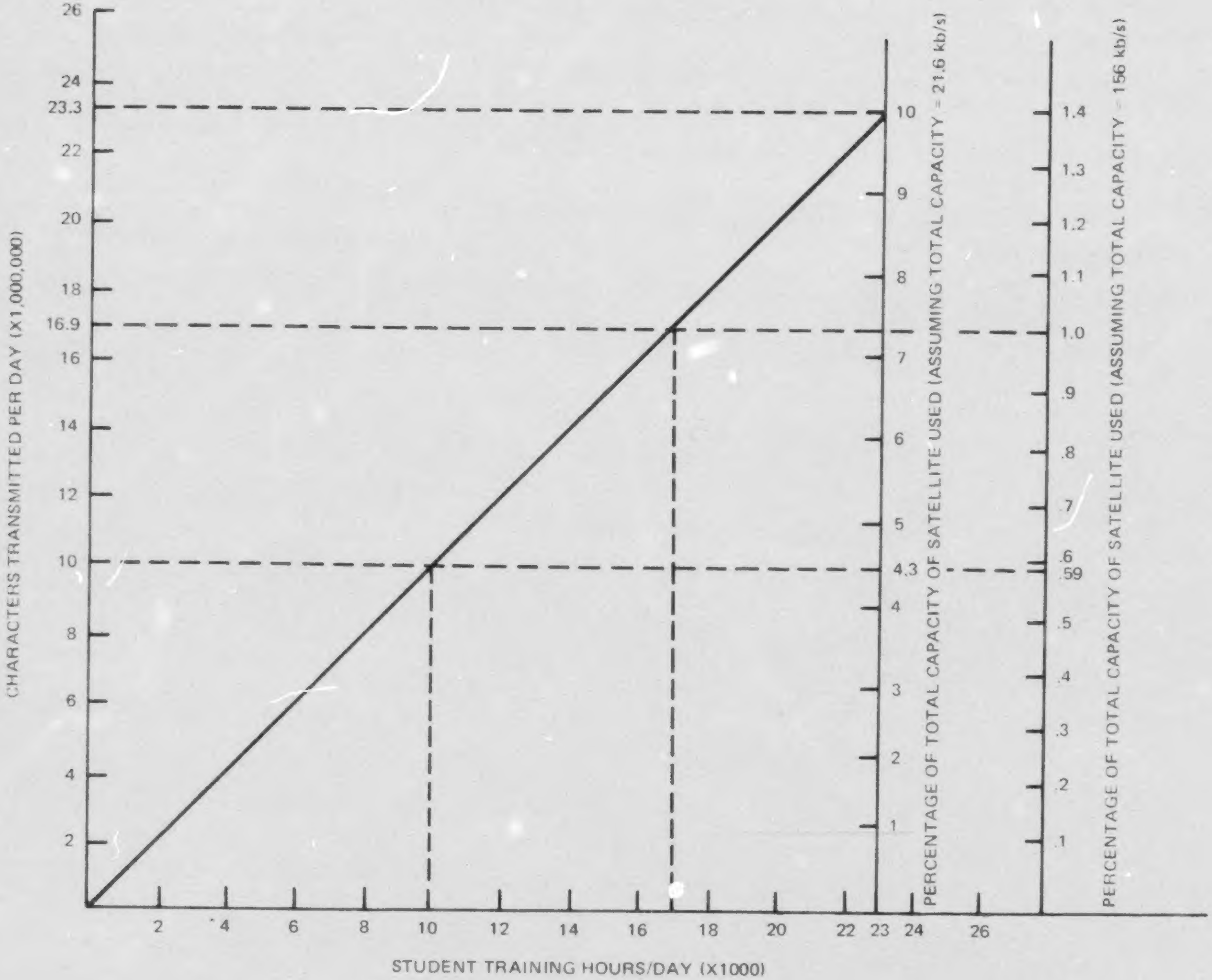

Figure IX-1. CMI Transmission Requirements

- ARPA-Net plus commercial telephone facilities. (Example: Hawaii.)

For shipboard CMI, the prime candidate is the FleetSatCom system with AUTODIN II, but other military and commercial satellites are, and will be, available. "Experimental" satellites, such as those in the Applications Technology Satellite (ATS) series, the Communications Technology Satellites (CTS) and Symphonie, are not included because they are not intended for operational use. For remote land site CMI, AUTODIN II is the prime candidate with the transmission facility to be determined by Naval Communications System operators.

This section discusses the alternative communications systems based upon the task statement in the project proposal.

1. Identification of Available Commercial and DoD Communications Systems

Since COMISAT transmissions require teletype channels, and since all communications satellites and systems are capable of handling teletype channels, the only factor limiting a given system is its ability to provide coverage of the Naval bases (see Appendix A for List and Locations). The same is true of possible terrestrial communications systems that might be used.

Systems that will be available for operational system use and their general coverage areas (see Appendix B) are as follows:

- FleetSatCom (UHF) satellites, which will provide worldwide coverage (except for polar regions) beginning in 1978.
- Defense Satellite Communications System II (DSCS II) satellites, providing worldwide coverage (except for polar regions) in conjunction with the NATO and Skynet (British) satellites. The DSCS II satellites are at 13°W and 175°E. The NATO II satellite,

at 23°W, supplements the service of the DSCS II at 13°W. Skynet at 55°W to 60°E provides Indian Ocean coverage.[1]

- Gapfiller (UHF), covering the Atlantic and Pacific Ocean areas from satellites at 15°W and 176.5°E and the Indian Ocean from a satellite at 73°E.[2] Gapfiller will be phased out of Navy service when FleetSatCom becomes operational.
- Other Naval Communications System facilities, providing worldwide coverage via HF and land lines (AUTODIN I).
- Westar system (including service on Westar available via American Satellite Corporation), providing land coverage of all 50 states from satellites located at 99°W and 123.5°W.
- RCA Satcom system, providing land coverage of all 50 states from satellites located at 119°W and 135°W.
- Comstar system, providing land coverage of all 50 states and Puerto Rico from satellites located at 95°W and 128°W.
- Marisat system, providing coverage to ocean vessels in the Atlantic and Pacific Oceans from satellites located at 15°W and 176.5°E. Coverage of the Indian Ocean will be added when suitable ground facilities have been built for commercial use of the satellite at 73°E.

2. Identification of Planned Commercial and DoD Systems

In addition to the systems listed above, the following systems or expansions are planned for the future:

- Defense Satellite Communications System III (DSCS III) satellites, providing worldwide coverage (except for polar regions) beginning in 1981, with all satellites operational by 1983.
- Satellite Business Systems (SBS), providing land coverage of the contiguous 48 states from a satellite located at 122°W.

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[1] Satellite location information was obtained from the Defense Communications Agency, Arlington, Virginia.

[2] The orbit locations of the Atlantic and Pacific GapSats may be adjusted in the future to provide more nearly uniform worldwide coverage, based upon information from the ComSat General Operations Center, Washington, D.C.

- NASA Public Services Satellite. This program is in the very early formative stages. Whether it will be available for training programs for service personnel remains to be seen.
- Expanded Naval Communications System, providing packet-switched communications via satellite, HF and land lines (AUTODIN II).
- Special DoD Training Satellite. Such a satellite has been suggested by the Office of the Assistant Secretary of Defense, Manpower and Reserve Affairs.

D. Communications Systems Compatibility with CMI System and Learning Audience Locations

As discussed earlier, there are two basic types of communications systems with respect to their compatibility with the CMI system:

- Systems that would be used in a manner that requires conversion to the Navy message system (AUTODIN II). These systems use the following transmission means:
    - FleetSatCom
    - Gapfiller
    - Defense Satellite Communications System II
    - Other Naval Communications Systems Facilities (e.g., HF)
    - Defense Satellite Communications System III
- Systems that are fully compatible with the present CMI system by virtue of providing the equivalent of a telephone line connection to the Memphis computer. These systems are:
    - A. T. & T. Long Lines
    - Marisat (ships)
    - Westar (including American Satellite) (land sites)
    - RCA SatCom (land sites)
    - Comstar (land sites)
    - Satellite Business Systems (SBS) (land sites)

  (Note: Intelsat is also a possible carrier, but Intelsat's purposes are civilian/commercial, not military. Therefore, a question exists as to the willingness of Intelsat to carry U.S. Navy CMI traffic.)

All of these communications systems listed have channel capacity limitations. The most serious limitations are on the FleetSatCom and Marisat systems, with HF channel capacity being highly variable depending on the terminal locations, time of day, month, and year. Because the most probable satellite system to be used is FleetSatCom, and because of its limited channel capacity, an examination of the portion of its capacity that an operational CMI system might require is included next.

1. FltSatCom Channel Capacity

The FltSatCom system will have nine channels, each 25 KHz wide, suitable for message traffic. Originally, each of the nine channels was to carry a 2.4 kb/s data rate. However, a Time Division Multiple Access (TDMA) system has been designed[1] which can provide a total of about 65 simultaneous 2.4 kb/s circuits on the nine 25 KHz channels, for an average data rate of 17.33 kb/s per channel for a "representative mixture of ships, aircraft, submarines and shore stations."

Present Navy plans are to use Channel 1 for Fleet Broadcast (15 channels of shore to ship Time Division Multiplex (TDM)), with the other channels computer controlled and interactive. Two CUDIXS channels will be provided. Each will serve ten major ships with duplex transmission, plus 50 small ships with ship-to-shore transmission.

A bit rate figure for the entire satellite has been derived but is not felt to be realistic "because of functional assignments--the number of people in the net and the traffic." Hence, while the actual FleetSatCom channel capacity is not yet established, it will be somewhere between 2.4 kb/s and 17.33 kb/s for each of the nine 25 KHz channels. Based on this, the total FleetSatCom capacity is between 21.6 kb/s and 156 kb/s.

2. High Frequency Transmission

In the event that high frequency (HF) transmission must be used for part of the path between the training location and the CMI computer in Memphis, special precautions must be taken to avoid the high error rates that can occur on HF transmission. Such precautions are the following:

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[1] J.D. Bridwell and I. Richer, "A Preliminary Design of a TDMA System for FleetSat," MIT Lincoln Laboratory, Group 67, Technical Note 1975-5, 12 March 1975, NTIS Document AD-A-007-823.

- Use a check sum digit after each block of numbers. This is a simple digit equal to the last digit of the sum of all the numbers in the block. (Error detection only)
- Use a formatted response in which all numbers (e.g., days, longitudes, etc.) in the text are repeated at the end of the message. Word errors are not detected by this method, but should be obvious to the reader. However, this method cannot handle the alpha-numeric equivalents of the OpScan output (teletype format) that will be sent from the OpScan unit to the CMI computer. (Error correction is accomplished if numbers are repeated at least three times and some correlation such as "two out of three determines correctness.")
- Repeat the message three times. (These repetitions should be ten to thirty minutes apart because errors in the HF transmissions occur in bursts.) (Error correction is accomplished if message is repeated at least three times and some condition such as "two out of three determines correctness" is used.)

The last approach, repeating the message three times, is the only useful method for the OpScan transmission to the computer because of the non-plain English nature of the alpha-numerics. For the CMI computer output, when response time is a problem, the second and third approach should be useful. The first approach requires a service message and repeat, requiring additional time.

3. Compatibility with Learning Audience Locations

Appendix A lists the worldwide U.S. Naval shore activity locations. All of them, in addition to ships, are potential learning audience locations. The DoD (including Navy) satellite systems provide the greatest compatibility on an overall basis with these learning audience locations because of their present or planned worldwide coverage. The non-DoD systems, with the exception of Marisat, are domestic commercial satellite systems which are limited in their coverage to the 50 states plus, in one case, Puerto Rico (SBS has no firm plans to cover Alaska or Hawaii). Only Marisat provides both full compatibility and worldwide coverage, but Marisat is intended for communication service to ships and off-shore drilling rigs rather than to "shore activities," so its use probably would be confined accordingly.

E. Operational Considerations and Cost

The operational system will use an OpScan unit, ruggedized for shipboard operation, to convert the test data to a digital electrical signal. As a back-up, chemically-treated answer sheets will be provided for use in the event of OpScan failure.

1. Operation Using AUTODIN

For use with the Naval Communications System, or other AUTODIN facilities, essentially the same operational procedure will be followed as will be used in the demonstration. The OpScan output will be connected to a teletype which will convert the CMI message into paper tape form to be sent to the Memphis CMI center. However, in the operational system, all CMI messages will be automatically transmitted directly to the CMI computer, eliminating the courier runs between the Memphis NAS TCC and the Computer Center, as in the demonstration. From there, the messages will be converted into the format used by the computer. The reverse path sequence will be used for the computer's reply to the shipboard or other remote learning center.

2. Operation Using Commercial or Other Non-Military Facilities

For use with satellite or other transmission systems that do not require conversion of the OpScan output to a teletype message, a shipboard satellite or other terminal will accept the OpScan output the same as a standard telephone line or 1200 baud data channel would, and will transmit this output to a land station. Here it is placed on the regular telephone direct dial network and sent to the Memphis CMI center, the same as transmissions from Great Lakes, San Diego, and Orlando. The reverse path sequence will be used for the computer's reply to the shipboard or other remote learning center.

If chemically-treated answer sheets are used during OpScan down periods, these sheets would have to be logged in and evaluated manually by the learning supervisor and transmission to Memphis held until the OpScan unit became operational again. In addition, the answer sheet marks would need to be of a consistency suitable for sensing by the OpScan. (Presently used chemical answer sheets are not suitable.) Alternatively, the learning supervisor could mark regular sheets based upon the way the students had marked the chemical answer sheets and then send them via the OpScan when it became available.

3. Communications System Cost Factors

The use of AUTODIN facilities, such as Gapfiller, DSCS, Naval HF facilities or FleetSatCom, would not entail any specifically assignable costs other than for manpower (operators on board ship plus software support at Memphis) and firmware[1] at Memphis. For a NASA Public Services Satellite or a DoD Training Satellite, the Navy probably would be expected to provide funding for operational shipboard satellite terminals. It is not likely that there would be any per channel usage costs, however.

Total system costs are shown in the tables to follow for the three basic alternatives:

Alternative I--Systems using Naval Communications or other U.S. military communications facilities.

Alternative II--Systems using non-commercial facilities independent of U.S. military communications systems.

Alternative III--Systems using commercial satellites.

In each case, total system cost, from both an installation and an operations and maintenance viewpoint, is the shore system cost plus m times the shipboard cost plus n times the remote land site cost, where m is the number of ships and n is the number of remote land sites. The cost factors shown are based upon cost data originally obtained for the demonstration system and revised, as necessary, for applicability to the operational system.

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[1] Firmware refers to needed extensions to the computer's instruction set that are done in read-only memory, which converts the new instructions to the basic instructions of the computer.

a. Alternative I (Use of Naval Communications or Other U.S. Military Communications Facilities)

Tables IX-1, IX-2, and IX-3 show the estimates for shore system, shipboard, and remote land site costs, respectively.

b. Alternative II (Use of Non-Commercial Facilities Independent of the Naval Communications System)

This category includes two possible future satellite systems, neither of which has been funded to date, but both of which are under consideration at present. They are:

- The NASA Public Services Satellite
- A DoD Training Satellite

The NASA Public Services Satellite might have coverage limited to the Western Hemisphere; the DoD Training Satellite System, if implemented, would more likely have worldwide coverage.

Alternative II requires the inclusion of earth station cost factors as well as costs associated with the learning site. The location of such an earth station for the Alternative II systems is not known, but it is assumed to be Rosman, North Carolina, for the NASA Public Services Satellite and a similar location (same distance from Memphis) for a DoD Training Satellite. Table IX-4 shows the estimated costs of such a system. Additional costs would be incurred at the Memphis CMI center since operation would be for telephone lines and terminations, plus the file creation costs for the new student cluster.

The means by which communication would be maintained with satellites serving other parts of the world than the Western Hemisphere

Table IX-1. Shore System Cost Factors – Alternative I

Equipment	Cost ($1000)	Personnel	Man-Hr./Wk.
1. CMI Computer Center to Memphis NAS TCC	Navy provides service	Navy provides service	–
2. CMI Computer Operation	Navy provides service	Navy provides service	–

Note: The assumption is made that training on board ship and at remote sites would be in lieu of training at present shore facilities. Therefore, there is no increase in total operating workload at the CMI center at Memphis.

Table IX-2. Shipboard Cost Factors – Alternative I

Equipment	Cost ($1000)	Personnel	Man-Hr./Wk.
1. SST (including Model 28 teletype)	Navy provides service	Navy provides service	
2. Classroom Equipment		Learning Supervisor operates	Depends on number of student training hours per week.
a. OpScan 17 (2)	2 @ 9.3 = 18.6	Navy ET maintains	2
b. Univ. Interface	2.0		
c. Spares	6.8		
TOTAL	27.4		

Note: Spares for the OpScan 17 cost $6.5K*. $300 is assumed for spares for the Universal Interface, which is needed to interface the OpScan 17 to the Model 28 Navy teletype.

*This cost is based upon the spares list furnished by OpScan and the prices currently being paid by GSA users for such items.

Table IX-3. Remote Land Site Cost Factors -- Alternative I

Equipment	Cost ($1000)	Personnel	Man-Hr./Wk.
1. Satellite terminal (including Model 28 teletype)	Navy provides service	Navy provides service	
2. Classroom equipment	-	Learning Supervisor operates	Depends on number of student training hours per week.
a. OpScan 17	2 @ 9.3 = 18.6	Navy ET maintains	2
b. Univ. interface	2.0		
c. Spares	6.8		
TOTAL	27.4		

Table IX-4. Shore System Cost Factors--Alternative II

Equipment	Cost[1]	Personnel	Man-Hr./Wk.
1. Memphis-Earth Station Circuit	$100 + $215/mo.	Technicians	21

[1] This cost is based upon A.T.&T. interstate tariffs.

Note: Ten or more learning sites are assumed, with transmissions 24 hours/day to and from various parts of the world. Accordingly, three work shifts are assumed, so the requirement is for seven hours/week from each of three technicians.

remains to be determined. Presumably, signals would be relayed from the Western Hemisphere satellite to one or more earth stations that are in view of other satellites which might or might not be part of the system. This means double-hop transmission. A DoD Training Satellite System probably would be arranged for worldwide coverage, while the NASA Public Services Satellite probably would have to be supplemented by another system (see Alternative III systems) for Eastern Hemisphere coverage, with its attendant additional costs.

Table IX-5 shows the estimated shipboard costs, while Table IX-6 shows the estimated remote land site costs.

Table IX-5. Shipboard Cost Factors – Alternative II

Equipment	Cost ($1000)	Personnel	Man-Hr./Wk.
1. SST (PRN, 24" dish)		Navy ET learns system	80 hours total
a. Investment	75 – 149	Navy ET operates	8 – 10
Second Antenna	15 – 30	Navy ET maintains	4 – 5
Sub-Total	90 – 179		
b. Installation	125 – 375		
c. Spares	18 – 36		
TOTAL 1	233 – 590		
2. Classroom Equipment		Learning Supervisor operates	Depends on number of student training hours per week.
a. OpScan 17	2 @ 9.3 = 18.6	Navy ET maintains	3
b. Univ. Interface	2.0		
c. OpScan spares	6.8		
d. Terminet 1200	2 @ 4.2 = 8.4		
e. Terminet spares	2.0		
TOTAL 2	37.8		

Note: SST costs are based upon estimates previously obtained for ATS-6 since no better basis exists for estimates at this time. These estimates are valid for an SST operating in the 1.5–1.6, 2.5–2.69, or 3.7–4.2 and 5.925–6.425 GHz bands.

Table IX-6. Remote Land Site Cost Factors – Alternative II

Equipment	Cost ($1000)	Personnel	Man-Hr./Wk.
1. Remote Terminal (8' dish)		Navy ET learns system	80 hours total
a. Investment	75 – 129	Navy ET operates	4 – 5
b. Installation	40 – 80	Navy ET maintains	3 – 4
c. Spares	15 – 26		
TOTAL 1	130 – 235		
2. Classroom Equipment		Learning Supervisor operates	Depends on number of student training hours per week.
a. OpScan 17	2 @ 9.3 = 18.6	Navy ET maintains	3
b. Univ. Interface	2.0		
c. OpScan spares	6.8		
d. Terminet 1200	2 @ 4.2 = 8.4		
e. Terminet spares	2.0		
TOTAL 2	37.8		

Note: Remote land site costs are based upon estimates previously obtained for ATS-6 since no better basis exists for estimates at this time. These estimates are valid for a remote terminal operating in the 1.6, 2.6, or 4-6 GHZ band. An 11-14 GHZ terminal might cost about ten percent more, based upon higher component costs.

c. Alternative III (Use of Commercial Satellite Systems)

Since the total number of ships and remote land sites that might use the system is not a known quantity at this time, the cost estimates in the tables to follow do not assume the high volume discounts available on commercial satellites. When details as to quantity of shipboard and land sites and their locations have been established, such cost discounts can be determined based upon the coverage of available domestic or other commercial satellites.

Present and possible future satellites in this category[1] are the following:

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[1] The information in this table was obtained from the FCC, Western Union, RCA, and Comsat during October, 1976, and from the EASCON Conference, September 27-29, 1976, Arlington, Virginia.

Satellite System	Country	Band (GHz)	Status
Westar	USA (land only)	4-6	Operational
RCA Satcom	USA (land only)	4-6	Operational
Comstar	USA plus Puerto Rico (land only)	4-6	Operational
Marisat	USA (all oceans)	1.6	Operational
Palapa	Indonesia	4-6	Operational
Anik	Canada	4-6	Operational
---	Brazil	4-6	Future
---	Colombia	4-6	Future
Advanced	USA (land only)	11-14	Approved by FCC, probably operational about 1980.
Westar	Indonesia	4-6 and 11-14	Future
MAROTS	European Space Agency (Atlantic and Indian Oceans)	1.6	Future
European Communication Satellite (ECS)	European Space Agency (Europe and Near East: land only)	4-6	Future
INSAT	India	?	Future
Communication Satellite (CS)	Japan	11-14	Future

Alternative III requires the inclusion of satellite channel costs in addition to earth station factors and learning site costs. In addition, as with Alternative II, costs will be incurred for communications via satellites covering the Eastern Hemisphere. Since the quantity and locations of the learning sites for an operational system have not been established, the cost factors shown in Table IX-7 are applicable to those sites within view of a Western Hemisphere satellite. Those sites requiring double-hop transmission (Eastern Hemisphere) will incur approximately twice the satellite and earth stations costs of the Western Hemisphere locations.

The quantity of shipboard sites served is expected to have an effect on satellite per channel costs because many satellite systems offer quantity discounts. In addition, a negotiated rate probably

Table IX-7. Shore System Cost Factors — Alternative III

Equipment	Cost	Personnel	Man-Hr./Wk.
1. Memphis-Earth Station Circuit	$100 + $215/mo.	Technicians	21

Note: The cost of circuits through the satellite is included in the shipboard and remote land site costs because different satellite systems are applicable, i.e., Marisat for ships at sea and Westar, RCA Satcom, or Comstar for remote land sites.

will be obtained because the shipboard terminals very likely will be Navy provided rather than owned by the carrier.

The only basis available for cost estimating at present is the published tariff applicable to Marisat. Accordingly, this is the basis of the satellite usage costs shown in Table IX-8.

The remote land site costs shown in Table IX-9 are based upon estimates previously obtained for domestic commercial satellites of USA ownership (Westar, RCA Satcom, Comstar). Costs for foreign domestic satellites, and their availability for U.S. Navy training missions, remain to be determined. The estimates are valid for a remote terminal operating in the 4-6 GHz Band. An 11-14GHz Band terminal might cost about 10 percent more, based upon higher component costs.

4. Examples of Cost Computation

a. Example 1

Assume that 50 shipboard terminals, each with 30 students on board, are to be operated based upon Alternative I. The shore system requires software changes at the Memphis CMI Computer Center. This one-time cost of two GS-12's and two GS-9's for a nine- to twelve-month period, estimated at $70,000, is assumed to have been incurred during the demonstration phase and hence is not included in Table IX-1 as part of the operational system costs.

Table IX-8. Shipboard Cost Factors — Alternative III

Equipment	Cost ($1000)	Personnel	Man-Hr./Wk.
1. Channel through Satellite	$10/student/week		
2. SST			
a. Investment	50 – 50	Navy ET operates	8 – 10
Second Antenna	15 – 30	Navy ET maintains	4 – 5
Sub-Total	65 – 80		
b. Installation	125 – 375		
c. Spares	10 – 10		
TOTAL 2	200 – 465		
3. Classroom Equipment		Learning Supervisor operates	Depends on number of student training hours per week.
a. OpScan 17	2 @ 9.3 = 18.6	Navy ET maintains	3
b. Univ. Interface	2.0		
c. OpScan spares	6.8		
d. Terminet 1200	2 @ 4.2 = 8.4		
e. Terminet spares	2.0		
TOTAL 3	37.8		

Note: The satellite usage cost is based on Marisat's published tariff of $10/minute and an estimated 0.2 minute/day/student usage, for $2/student/day or $10/student/week for a five-day week.

The shipboard cost is as follows:

Classroom Equipment @ $27.4K/ship x 50 ships = $1,370,000

While at least 50 learning supervisors will have to be designated at the 50 sites, the exact number of additional billets required will depend upon the number of student training hours per week at each site.

b. Example 2

Assume that 50 remote land terminals each with 30 students are to be operated based upon Alternative III. Half of the terminals are in the Western Hemisphere, while half are in the Eastern Hemisphere.

Table IX-9. Remote Land Site Cost Factors – Alternative III

Equipment	Cost ($1000)	Personnel	Man-Hr./Wk.
1. Channel through Satellite	$1.1/month[1]		
2. Remote Terminal (8' dish)		Navy ET learns system	80 hours total
a. Investment	75 – 129	Navy ET operates	4 – 5
b. Installation	40 – 80	Navy ET maintains	3 – 4
c. Spares	15 – 26		
TOTAL 2	130 – 235		
3. Classroom Equipment		Learning Supervisor operates	Depends on number of student training hours per week.
a. OpScan 17	2 @ 9.3 = 18.6		
b. Univ. Interface	2.0	Navy ET maintains	3
c. OpScan spares	6.8		
d. Terminet 1200	2 @ 4.2 = 8.4		
e. Terminet spares	2.0		
TOTAL 3	37.8		

[1] A single channel will accommodate a student load of 840 students total on the system on the basis of one minute/student/week average, and a five-day week. These students may or may not all be at one site. For a different number of students at a site, the per site cost should be adjusted accordingly. The $1100/month tariff is for one audio channel both ways over a 1,000 to 1,900 mile distance. For less than 1,000 miles, the tariff rate is $1000/month, while for distances in excess of 1,900 miles, the rate is $1500/month. Quantity discounts and a lower negotiated rate are reasonable expectations.

The total student load per satellite is 750, so the $1500/month rate is assumed for the Western Hemisphere satellite, since many of the distances may be in excess of 1,900 miles, while $3000/month is assumed for the Eastern Hemisphere satellite, based upon double-hop operations.

Remote terminals are assumed to cost an average of ($130 + $235)K/2 each, or $182,500, for a total of $182,500 X 50 = $9,125,000. A total of eight hours per week of Navy Electronics Technician time is required to operate and maintain each terminal.

Classroom equipment costs will total \$37,800 X 50 = \$1,890,000.

In summary:

Satellite lease:	\$4,500/month
Remote terminals:	\$9,125,000
Classroom equipment:	\$1,890,000
Personnel:	50 ET's @ 8 hr./wk. each At least 50 designated learning supervisors (the exact number of additional billets required will depend upon the number of student training hours per week at each site)

F. DoD Policies that May Affect Uses of Satellite Systems

To determine whether any existing DoD policies might have an impact on the operation of a COMISAT-type system, Joint Chiefs of Staff (JCS) Policy Memo 178 was reviewed. This document, "Policy on Military Satellite Communications Systems," deals, among other things, with the "general policy for utilization of MilSatCom systems," and "provides policy and guidance relative to...priority and apportionment of MilSatCom systems capacity,...and...validation and prioritization of user requirements for MilSatCom systems."

Much of JCS Policy Memo 178 deals directly or indirectly with the Defense Satellite Communications System (DSCS). Of concern with respect to systems such as FleetSatCom, however, are the following points:

Para. 8.d(4) states that "requirements of the National Command Authorities (NCA) and the Joint Chiefs of Staff" will take precedence over "service (Navy) communications satellite requirements and those of all other users of the system."

Para. 8.d(7) states that "the U.S. Navy will exercise operational control of the FleetSatCom system," with operational control being defined by DoD Directive 510.44. The Navy will also exercise operational control over U.S. Navy shipborne terminals, whether they access DSCS or FltSatCom, or both.

During crises, circuits for CMI purposes probably will not be available.

Para. 8.g states that "unresolved differences among participants in the MilSatCom systems organization with respect to responsibilities and functions, validations and prioritization of user requirements, apportionment of satellite communications capacity, and control in MilSatCom systems, unless provided for in this or other directives, will be referred to the Joint Chiefs of Staff for resolution."

The temporary apportionment of satellite communications capacity during crises by the JCS will be based upon its determination that "the particular user requirement is valid and must be fulfilled."

A System Concept of Operations is to be developed by the executive agent of each MilSatCom system, i.e., by DCA for DSCS, by the Navy for FltSatCom, by [illegible] Air Force for AFSatCom, etc. This document will, among other things, contain information on "user precedence and priority in fulfilling validated communications requirements," as well as "procedures to accommodate the apportionment of operational satellite communications capacity to reflect the temporary dynamic variations in national defense needs caused by crises, or anticipated as contingencies."

G. Procedures for Obtaining Use of Desirable Satellite Systems

The procedures for obtaining the use of Alternative I systems (Naval Communications System facilities) are outlined in JCS Policy Memo 178. This memo indicates in Para. 15.c that the Service (U.S. Navy) specifies the use, location and application of its terminals (excluding DSCS). The "utilization and function of these terminals, responsive to specific U.S. national security and Service (Navy) requirements, will be included in appropriate Service (Navy) program/systems plans documents. The program/ system plans, if originated by a Defense agency or by a Service other than the one which is designated as executive agent for a particular MilSatCom system, will be coordinated with that executive agent and supported by an operational plan to be included in the System Concept of Operations."

In general, the procedure for Gapsat or FltSatCom involves entering the messages as standard Navy messages.

Para. 8.d(2) of JCS Policy Memo 178 states, "Requests for new DSCS service will be forwarded to DCS, who, in turn, will evaluate the capability to satisfy the request via the DSCS. New DSCS service is defined as satellite connectivity requirements from a new or existing terminal location...." Such requests "will be submitted with recommendations for satisfaction to the Joint Chiefs of Staff for validation and approval."

Procedures for obtaining the use of Alternative II systems (noncommercial facilities independent of the U.S. military communications facilities) cannot be stated because the two systems in this category, the NASA Public Services Satellite and a possible DoD Training Satellite, have not yet completed the preliminary planning stages.

Procedures for obtaining the use of Alternative III systems (commercial satellites) vary with the satellite system. JCS Policy Memo 178 states in Para. 16 that "the executive agent of each MilSatCom system (e.g., Gapsat, FltSatCom, etc.) will insure that the Joint Chiefs of Staff are kept informed with regard to the shared use of assets and services...including the use of commercial assets and satellite systems governed by leasing arrangements."

Precedence already exists for the lease of commercial facilities by U.S. defense agencies. For example, three Air Force bases, the

Centerville Beach (California) Naval Station, and Moffett Field all have dedicated earth stations served by the American Satellite Corporation.

Where dedicated terminals are involved, as would be the case with an operational CMI system, satellite usage charges are negotiated with the carrier, assuming the carrier is a USA entity. If a foreign carrier is involved (e.g., Canadian, European, or other), the willingness of the country involved would also have to be determined.

H. Viable Communications Systems Alternatives

The viable satellite alternatives have been categorized previously. Use could be made of ATS-1 and -3 as well as ATS-6, and possibly the Communications Technology Satellite (CTS), but these are experimental, rather than operational, satellites. Aerosat will have communication with aircraft as its primary purpose and is therefore not considered as a viable alternative.

The use of the AUTOVON, as distinguished from AUTODIN, circuits is a possibility, but not a good one since the AUTOVON circuits are in heavy demand for voice requirements, their primary function.

The most viable communications system alternatives are felt to be the systems in the Alternative I category, e.g., Gapfiller, FltSatCom, and DSCS, in conjunction with Naval Communications System shore facilities, which include HF systems for back-up purposes.

Appendix IX-A

U.S. NAVAL SHORE ACTIVITY LOCATIONS OUTSIDE THE FIFTY STATES

References: "Catalog of Naval Shore Activities," Section 3, "Shore Activities by Area Coordination," Edition 62, 1 January 1976, Office of the Chief of Naval Operations, Department of the Navy, Washington, D.C. 20350, pp. 221-224.

"Personnel of the Naval Shore Establishment," Manpower Information Division, Office of Civilian Manpower Management, Department of the Navy, NAVSO P-111, December 1975, pp. 20-51.

The two references use somewhat different location designations at times. To prevent duplication, therefore, the numbers of military personnel outside the fifty states as enumerated in the second reference are listed below, together with their designated locations. They are grouped, for convenience, however, by the areas of the first reference.

Shore Activity Locations: U.S. Atlantic Fleet	Military Personnel
Lajes, Azores	152
Bermuda	822
Guantanamo Bay, Cuba	1,517
Roosevelt Roads, Puerto Rico	1,415
Argentina, Newfoundland	369
Keflavik, Iceland	1,089
Fort Amador, CZ	186
Ponce, Puerto Rico	238
Rio de Janeiro, Brazil	16
Galeta Island, CZ	35
Sabena Seca, Puerto Rico	251
Rodman, CZ	54
San Juan, Puerto Rico	28
Subtotal	[illegible],172

Shore Activity Locations: U.S. Pacific Fleet	Military Personnel
Atsugi, Japan	507
Guam, Mariana Islands	2,050
Subic Bay, Luzon, Republic of the Philippines	2,315
Taipei, Republic of China	355
Yokosuka, Japan	889
Exmouth, Western Australia	308
San Miguel, Luzon, Republic of the Philippines	247
Bangkok, Thailand	36
Manila, Republic of the Philippines	14
Sasebo, Japan	134
Singapore	10
Okinawa Prefecture, Japan	542
Iwakuni, Japan	103
Seoul, Korea	36
Yokohama, Japan	27
Chinhae, Korea	39
Djakarta, Indonesia	10
Yungsan, Korea	22
Tokyo, Japan	13
Midway Island	522
Subtotal	8,179

Shore Activity Locations: U.S. Naval Forces, Europe	Military Personnel
London, England	225
Rota, Spain	1,076
Naples, Italy	1,066
Catania, Sicily	572
Machrihanish, Scotland	31
Kenitra, Morocco	310
Londonderry, Northern Ireland	214
Nea Makri, Greece	288
Sidi Yahia, Morocco	255
Madrid, Spain	8
La Maddalena, Sardinia, Italy	33
Addis Ababa, Ethiopia	13
Cairo, Arab Republic of Egypt	19
Bremerhaven, Germany	24
Thurso, Scotland	55
Bahrein	30
Holy Loch, Scotland	4
Subtotal	4,223
Total	18,574

Appendix IX-B

COVERAGE AREAS OF COMMUNICATION SATELLITE ALTERNATIVES

The maps in this appendix show the "footprint" coverage areas of many of the satellite systems discussed in this report. This coverage area information can be used in conjunction with the data in Appendix A and information on the population of U.S. naval vessels at sea to determine the number of U.S. military personnel that could be provided CMI via each of the satellite systems.

Satellites with "global" or "earth coverage" beams are assumed to produce signals usable to receiving site elevation angles as low as 5°. This is a conservative assumption based on Gapfiller experience to date. Similar results have been obtained with commercial (4-6GHz) satellites.

The footprints shown are as follows:

Figure	Satellite System
IX-B-1	Gapsat/Marisat
IX-B-2	FltSatCom
IX-B-3	DSCS, NATO II and Skynet
IX-B-4	Westar
IX-B-5	RCA Satcom
IX-B-6	Comstar
IX-B-7	Anik
IX-B-8	Palapa

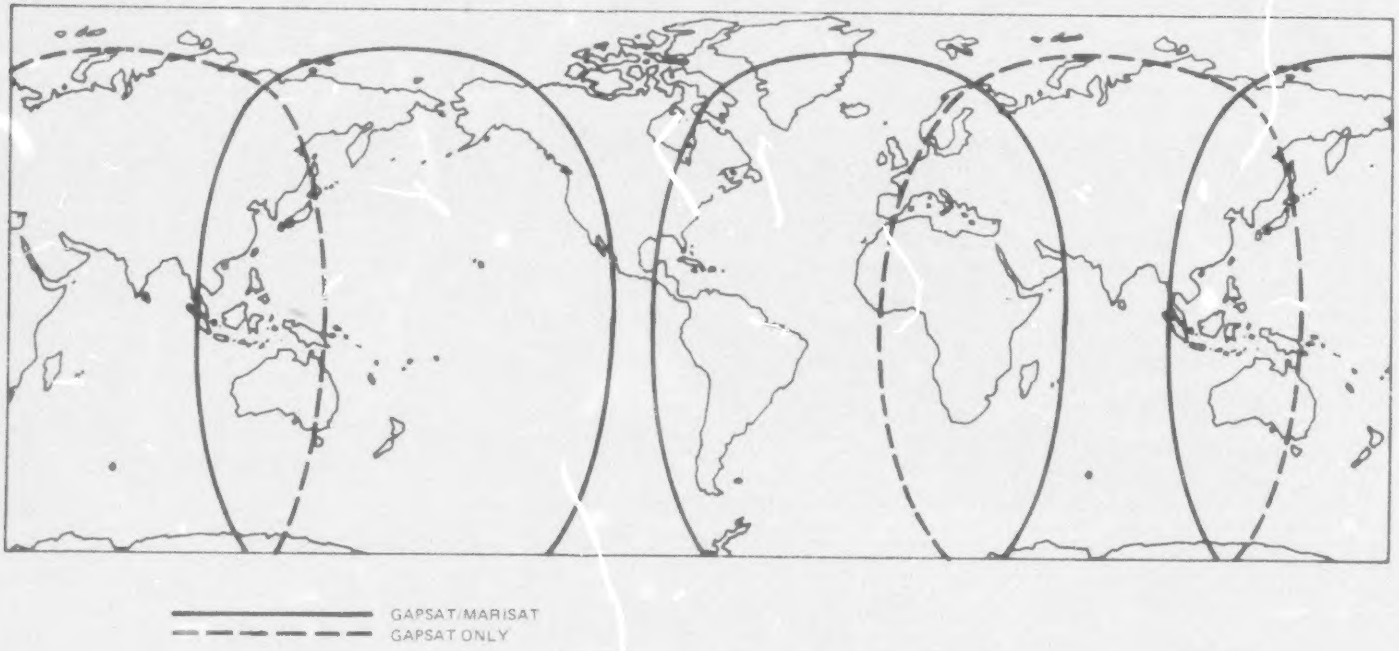
GAPSAT/MARISAT
GAPSAT ONLY

Figure IX-B-1. Gapsat-Marisat Coverage

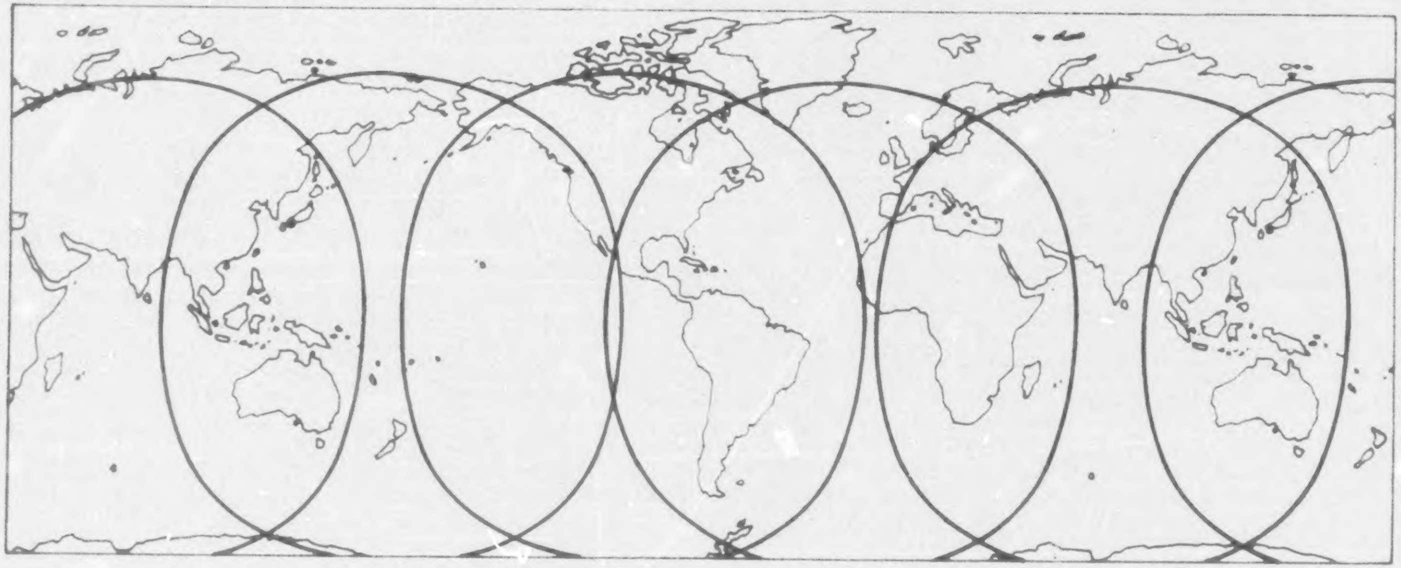

Figure IX-B-2. FleetSatCom Coverage (Planned)

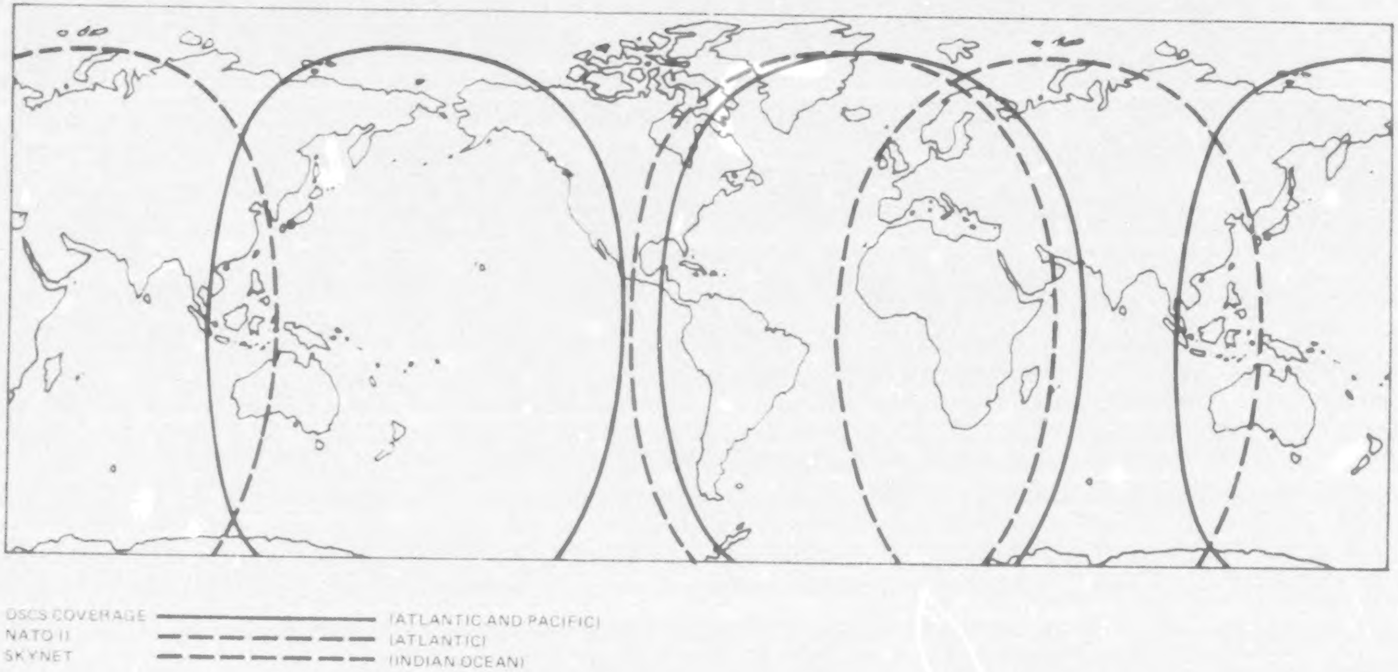
DSCS COVERAGE
(ATLANTIC AND PACIFIC)
NATO II
(ATLANTIC)
SKYNET
(INDIAN OCEAN)

Figure IX-B-3. DCSC, NATO II and SKYNET Coverage

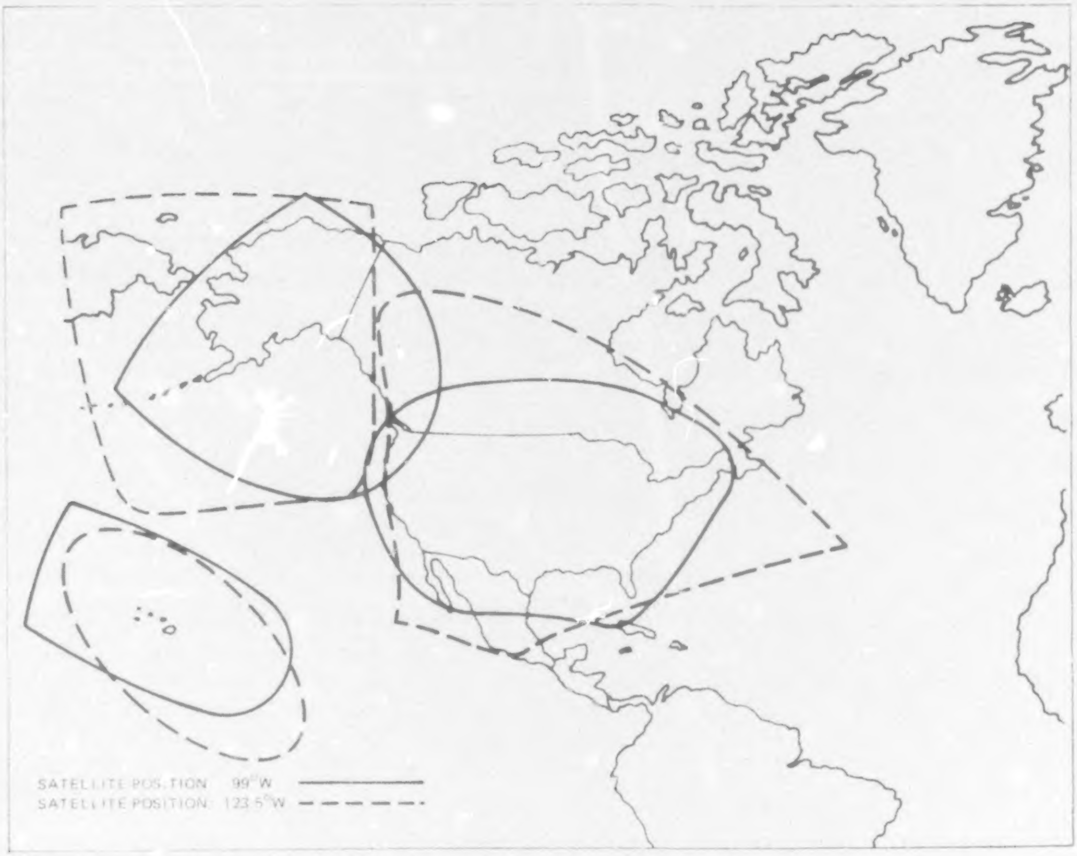
SATELLITE POSITION: 99°W ——
SATELLITE POSITION: 123.5°W – – – –

Figure IX-B-4. Westar Coverage

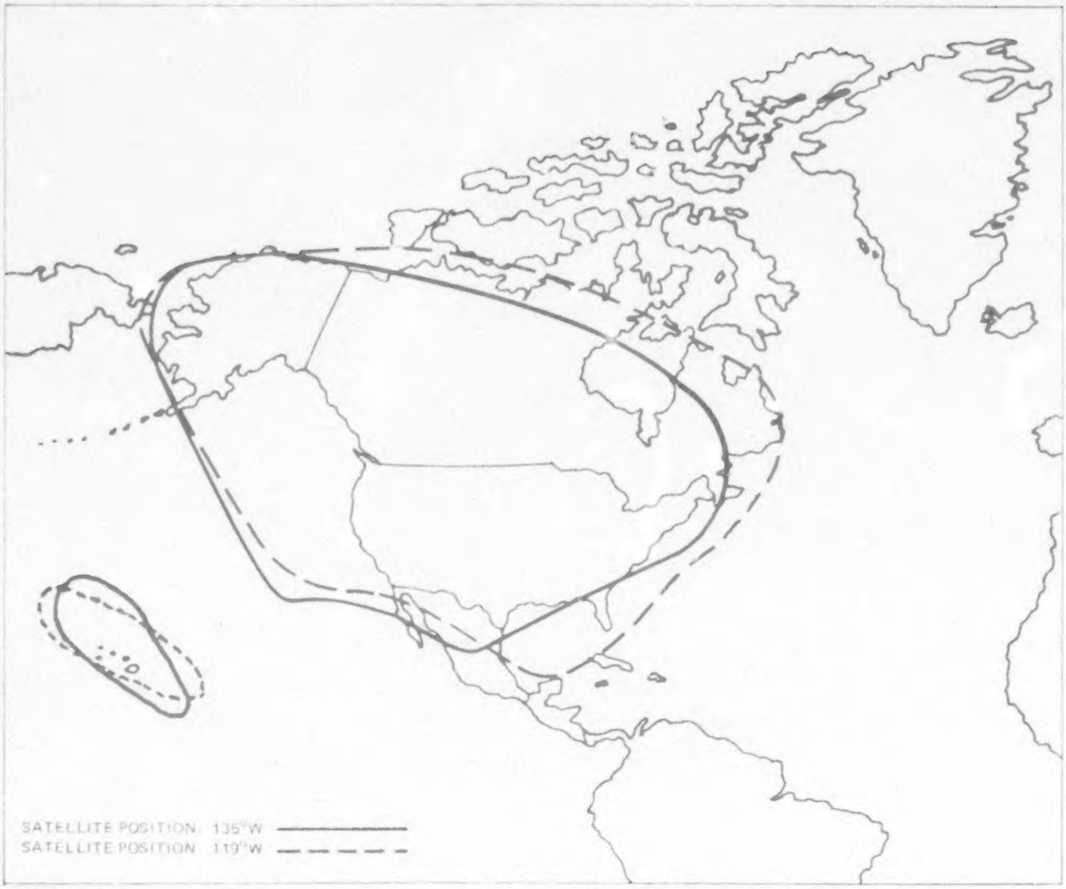
SATELLITE POSITION 135°W ————
SATELLITE POSITION 119°W — — — —

Figure IX-B-5. RCA Satcom Coverage

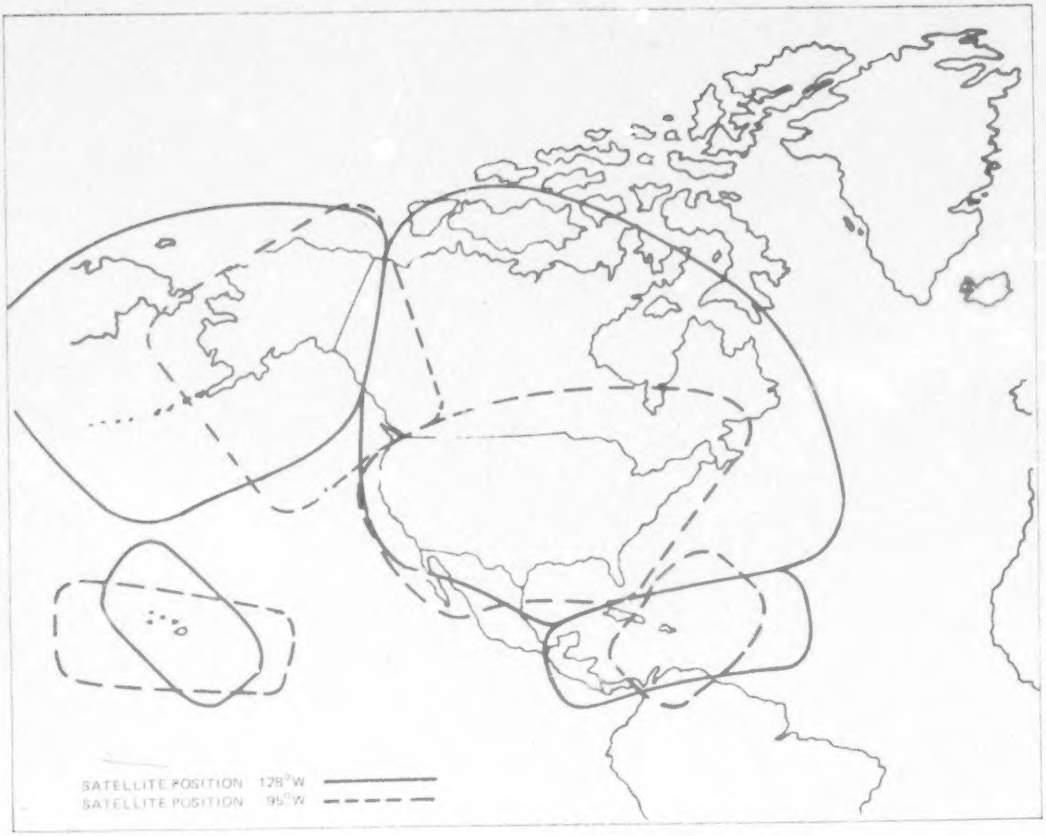
SATELLITE POSITION 128°W ———
SATELLITE POSITION 95°W - - - - -

Figure IX-B-6. Comstar Coverage

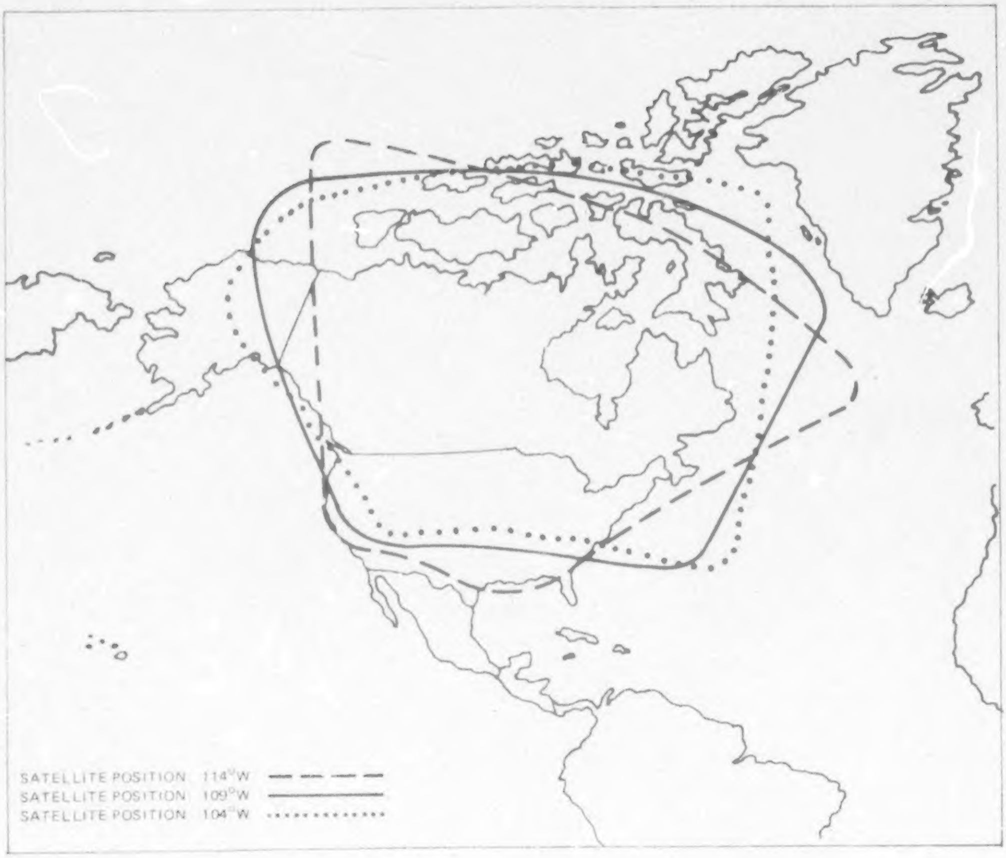
SATELLITE POSITION 114°W
SATELLITE POSITION 109°W
SATELLITE POSITION 104°W

Figure IX-B-7. Anik Coverage (Telesat-Canada)

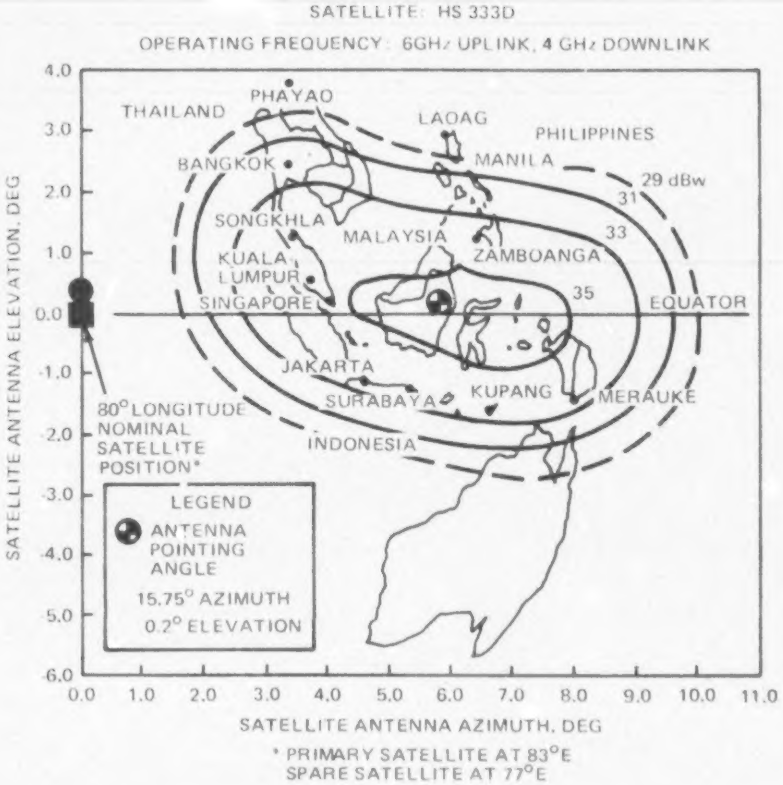
SATELLITE: HS 333D
OPERATING FREQUENCY: 6GHz UPLINK, 4 GHz DOWNLINK
SATELLITE ANTENNA ELEVATION, DEG
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
5.0
-6.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
SATELLITE ANTENNA AZIMUTH, DEG
THAILAND
PHAYAO
LAOAG
PHILIPPINES
BANGKOK
MANILA
29 dBw
31
33
35
SONGKHLA
MALAYSIA
KUALA LUMPUR
ZAMBOANGA
SINGAPORE
EQUATOR
JAKARTA
SURABAYA
KUPANG
MERAUKE
INDONESIA
80° LONGITUDE NOMINAL SATELLITE POSITION*
LEGEND
ANTENNA POINTING ANGLE
15.75° AZIMUTH
0.2° ELEVATION
* PRIMARY SATELLITE AT 83°E
SPARE SATELLITE AT 77°E

Figure IX-B-8. Palapa Coverage

Appendix IX-C

NAVAL INSTALLATIONS WITHIN THE UNITED STATES

Reference: "Personnel of the Naval Shore Establishment," Manpower Information Division, Office of Civilian Manpower Management, Department of the Navy, NAVSO P-111, December 1975.

The following locations within the United States have the numbers of military (Navy and Marine) permanent cadre personnel shown. (Locations listed are those which also employ civilian personnel.) Based upon the "Technical Notes" in the referenced document, military personnel at a location temporarily for training purposes only are believed not to be included in the data shown. The "Technical Notes" read as follows:

> The civilian statistics in this publication are compiled from three major sources: (1) Monthly Report of Personnel Data, Form NAVSO 12280/12; (2) Personnel Automated Data System (PADS); and (3) recurring or one-time special reports. Civilian personnel data cover direct-hire civilian employees in the United States, territories and foreign countries unless otherwise designated. The data exclude the following categories: those on leave without pay for scheduled periods longer than 30 days; persons carried in any kind of leave status after the last day of active duty as specified in a reduction-in-force notice; disadvantaged youths under the Stay-in-School Campaign and the Summer Aid Program; Public Service Career employees from the worker-trainee register; employees in developmental jobs; persons working without compensation; and persons serving at $1.00 per year.
>
> Military personnel data at those activities which employ civilians have been compiled from data furnished by the Bureau of Naval Personnel for Navy personnel. In some instances the data have been aggregated to conform to the definition of an activity in the Personnel Automated Data System (PADS).

Following the list is a map (Figure IX-C-1) showing the geographical locations of the corresponding Navy installations.

Location	Personnel
Alabama	
Dothan	3
Montgomery	76
Alaska	
Adak	918
Arizona	
Yuma	848
Arkansas	
Little Rock	76
California	
Barstow	677
Camp Pendleton	986
China Lake	34
El Centro	67
El Toro	1,621
Ferndale	181
Lemoore	862
Los Angeles Area (Long Beach, Pomona, Seal Beach, Los Alamitos)	1,352
Monterey/Big Sur	480
Pt. Mugu	768
Port Hueneme	784
San Diego Area (Coronado, Miramar, Imperial Beach)	23,313
San Francisco Area (Alameda, Concord, Oakland, San Bruno)	3,612
Santa Ana	234
Sonora/Vallejo	855
Stockton	286
Sunnyvale/Moffett Field	578
Tupman	4
Twenty-Nine Palms	2,590
Colorado	
Denver	192
Connecticut	
East Hartford	4
Groton/New London	2,161
Stratford	5

Location	Personnel
Delaware	
Lewes	101
District of Columbia	
Washington Area (Arlington, VA, Alexandria, VA, White Oak, MD, Suitland, MD, Falls Church, VA, Silver Spring, MD)	8,379
Florida	
Cecil Field	1,496
Homestead	247
Jacksonville/Mayport	2,795
Key West	1,197
Miami	72
Milton/Whiting Field	1,882
Orlando	603
Panama City	122
Patrick AFB	107
Pensacola/Saufley Field	4,168
Georgia	
Albany	805
Athens	105
Atlanta	418
Glynco	1
Macon	35
Hawaii	
Halawa Heights	496
Kaneohe Bay	567
Pearl Harbor/Barber's Point	4,423
Wahiawa	862
Idaho	
Idaho Falls	42
Illinois	
Chicago Area (Great Lakes, Glenview)	2,024
Indiana	
Crane	42
Indianapolis	106
Iowa	
Des Moines	79

Location	Personnel
Kentucky	
Louisville	100
Louisiana	
New Orleans (Belle Chasse)	1,070
Maine	
Brunswick Area (Bath, Topsham)	535
East Machias	91
Winter Harbor	327
Maryland	
Annapolis	562
Bainbridge	134
Baltimore	2
Fort Meade	92
Indian Head	221
Patuxent River Area (St. Indigoes)	2,016
Massachusetts	
Boston Area (Natick)	164
Chelsea	15
South Weymouth	317
Michigan	
Detroit	158
Mt. Clemens	171
Minnesota	
Minneapolis	132
Mississippi	
Gulfport	391
Meridian	1,376
Pascagoula	53
Missouri	
Kansas City Area (Overland Park, Kansas)	673
St. Louis	115
Nebraska	
Omaha	73
Nevada	
Fallon	494

Location	Personnel
New Hampshire	
Pittsfield	5
Portsmouth	135
New Jersey	
Bayonne	7
Colt's Neck	83
Lakehurst	390
Trenton	7
New Mexico	
Albuquerque	216
White Sands	96
New York	
Albany/Scotia	173
Bethpage	10
Buffalo	140
New York City Area (Brooklyn, Carle Place, Garden City, Great Neck)	1,366
North Carolina	
Asheville	2
Buxton	133
Camp Lejeune	6,277
Cherry Point	1,122
New River	357
Raleigh	90
Ohio	
Akron	1
Cincinnati	10
Cleveland	201
Columbus	157
Oklahoma	
McAlester	34
Oklahoma City	70
Oregon	
Charleston	104
Portland	118
Pennsylvania	
Mechanicsburg	119
Pittsburgh	106
Philadelphia Area (Camden, New Jersey)	3,259
Yorktown	6

Location	Personnel
Rhode Island	
Davisville	5
Newport	1,160
South Carolina	
Charleston	2,624
Columbia	71
Parris Island/Beaufort	10,355
Tennessee	
Memphis/Millington	2,876
Nashville	68
Texas	
Beeville/Chase Field	1,365
Corpus Christi	2,079
Dallas	466
Houston	76
Kingsville	1,418
Orange	8
San Antonio	77
Virginia	
Dahlgren	15
Dam Neck	1,369
Norfolk Area (Portsmouth, Newport News, Hampton, Oceana, Little Creek)	9,948
Quantico	5,486
Richmond	77
Williamsburg/Yorktown	394
Washington	
Bangor	1
Keyport	228
Oso	1
Pacific Beach	106
Seattle Area (Brementon, Bellevue, Silverdale)	1,022
Whidbey Island	841
Wisconsin	
Milwaukee	103
Sturgeon Bay	2
Wyoming	
Casper	1

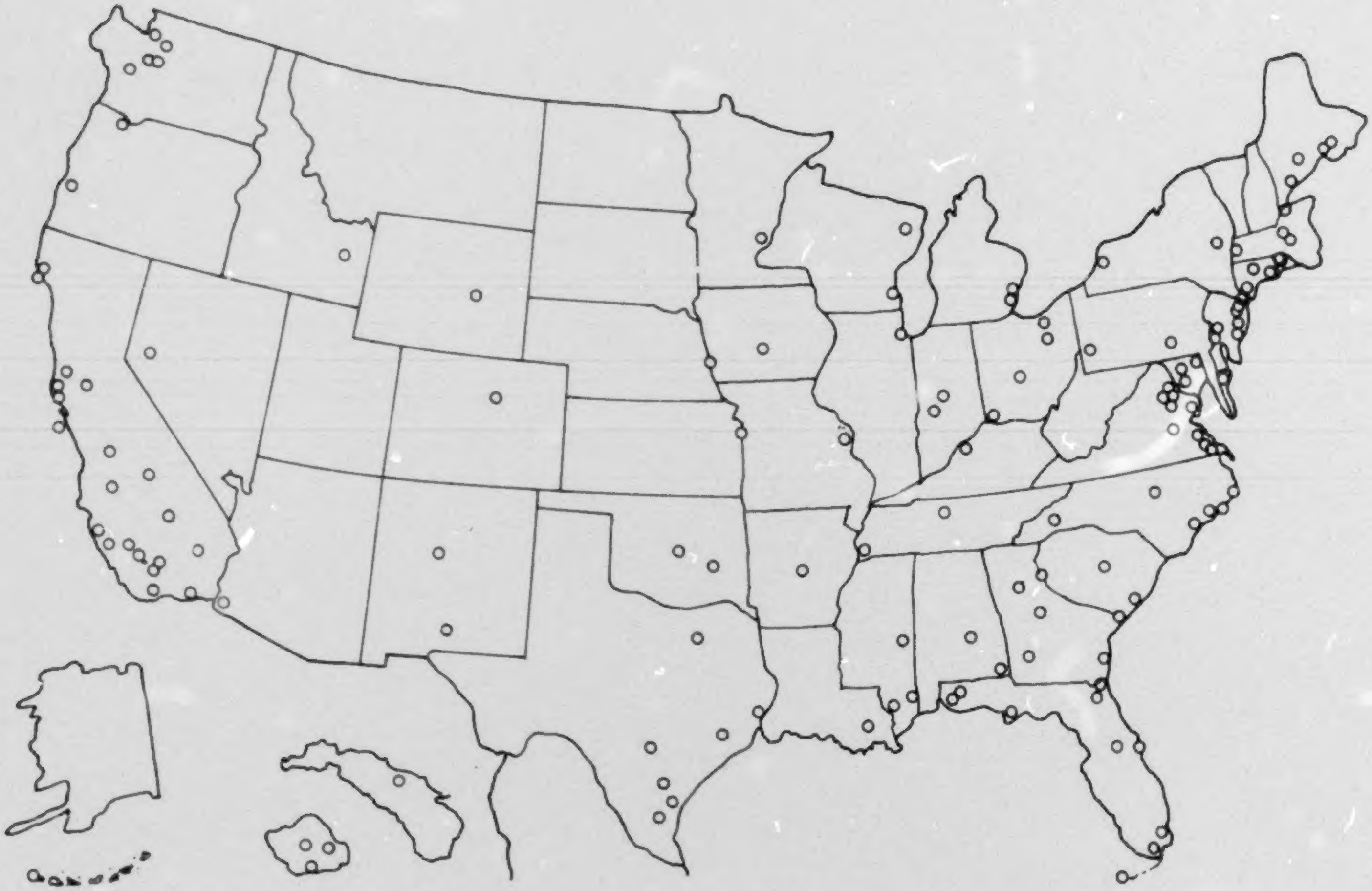

Figure IX-C-1. Geographical Locations of Navy Installations Within the United States

Chapter X

CONCLUSIONS AND RECOMMENDATIONS

A. Introduction

This chapter summarizes the conclusions reached as a result of the Feasibility Study and recommends future courses of action. The conclusions are treated in eight categories: the demonstration communications system; demonstration technical feasibility; resource requirements; operationalizing project objectives; CMI courses; demonstration design characteristics; project schedule; and operational potential of the COMISAT concept.

B. Conclusions

1. Communications System

The U.S. Navy communications system should be used for the demonstration. This conclusion is based on the following factors:

- The Navy communications link would be less costly to use than any alternative communications link.
- The U.S. Navy possesses a worldwide, highly reliable communications system which could be used to communicate between almost any demonstration site and the Computer Center in Millington, Tennessee.
- It is likely that an operational CMI support system would use the existing Navy communications system.

2. Technical Feasibility

The proposed demonstration is technically feasible and can be operationalized with existing hardware and within the current Navy communications system.

- No additional telecommunications hardware would be required at the demonstration site, Computer Center, or Millington T.C.C.

- A dedicated communications channel would not be required; it would be possible for CMI-related messages to be part of normal message traffic flowing to and from a demonstration site.

- The addition of message units to the system would be minimal for the demonstration period, requiring the handling of only 62 messages per day, two emanating from the demonstration site, 60 returning from the Computer Center.

- The computer system would be able to process the demonstration data without additions to the mainframe or peripheral equipment.

- The flow of data over the system, the interface requirements, and related processes have been analyzed and pose no problems for COMNAVTELCOM, NETISA, CNTT or CNET in general.

- Navy personnel normally associated with the training and communications functions would be able to perform the required functions with little or no additional training.

3. Resource Requirements

The additional resource requirements for the conduct of the demonstration are relatively small and should pose no major obstacle.

- Hardware requirements consist of the installation of one small OpScan 12/17 at the demonstration site, and if one does not exist, the installation of a UGC-6 at the Computer Center and demonstration site.

- Support personnel requirements consist of one or two learning supervisors, to be provided to the demonstration site by CNET; one site member to provide OpScan maintenance two hours per week; and one Computer Center person to manage the communications system and contractor interfaces.

- Site space requirements consist of: space for a small amount of learning materials, AV equipment, and OpScan spare parts; a working area for two or three students and a supervisor; and housing for 30 individuals if new personnel are selected to be demonstration subjects.

- Software support requirements consist of computer programs to handle the input, storage, and output of demonstration subject data and information.

4. Operationalizing Project Objectives

Each objective can be realistically operationalized and the associated data collected. However, except for Objective 1, which has the related data collection computerized via the CMI system, attention will need to be given to constructing data gathering methodologies. Objective 3, which addresses the economic analysis, is the most comprehensive and will be the most difficult.

5. CMI Courses

The available or soon to become available CMI courses would be adequate for the purpose of the demonstration.

- Basic Electricity and Electronics is operational, along with the common core for Boiler Technician, Machinist Mate and Engineman; these courses would probably be more useful if existing personnel who missed such training or who wish to study for new rates were used as demonstration subjects.
- The Radioman course is to be available in the fall of 1977 and would be appropriate for either new or existing personnel.

6. Demonstration Design Characteristics

A research design can be developed which would yield the desired project results.

- Both land and sea sites have training requirements that might be supported with a centralized CMI system.
- New or existing personnel could be used to determine the impact of the operational environment on CMI-supported training.
- To determine if partially trained A-school personnel can receive the remainder of the CMI-supported training at a job site and also to determine if a centralized CMI system can support operational site training, an A-school course would need to be used for the demonstration and an A-school class selected to serve as the control group.
- A sample size of 60 subjects would suffice, with 30 in the control and 30 in the experimental group.

7. Project Schedule

Keeping the original project schedule is highly unlikely. The earliest possible start date now appears to be January 1978 for the trial run and February 1978 for the demonstration, the reasons being:

- A demonstration site was not provided during the Feasibility Study, thus requiring that most associated design work, such as courseware and demonstration subject selection and computer software development, be delayed.
- The last 2 weeks of December are usually disrupted due to leave and other activities.

8. Operational Potential

Technically, it is possible to operationalize the COMISAT concept, since the present and future Navy communications and NETISA computer systems would be able to support some remote site training.

- As noted above, a dedicated communications channel is not required, and CMI data can be handled as normal message traffic.
- Any communications and computer capacity available for remote site CMI support would more than likely be used for critical training areas until a more dedicated system evolves.
- The basic concept of CMI support for training would not change, but its application and procedures for use would change because of its functioning in an operational environment rather than in a schoolhouse; thus, student feedback, number of lessons considered per day, and the learning supervisor role could change.

C. Recommendations

Based on the conclusions reached as a result of the Feasibility Study, the following recommendations are made:

- Pursue the project into the Design Phase.
- Continue to seek a demonstration site--land or sea--for the conduct of the demonstration.
- If a demonstration site is not designated within the Design Phase, terminate the project.

- If a demonstration site is designated within the Design Phase, plan for a January or February 1978 demonstration start date.

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